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A N E S S A Y
T O W A R D S A
SYSTEM OF MINERALOGY.

By AXEL FREDERIC CRONSTEDT,
MINE-MASTER OR SUPERINTENDANT OF MINES IN SWEDEN.

TRANSLATED FROM THE ORIGINAL SWEDISH,
WITH ANNOTATIONS, AND AN ADDITIONAL TREATISE ON
THE BLOW-PIPE.

By GUSTAV VON ENGESTROM,
COUNSELLOR OF THE COLLEGE OF MINES IN SWEDEN.

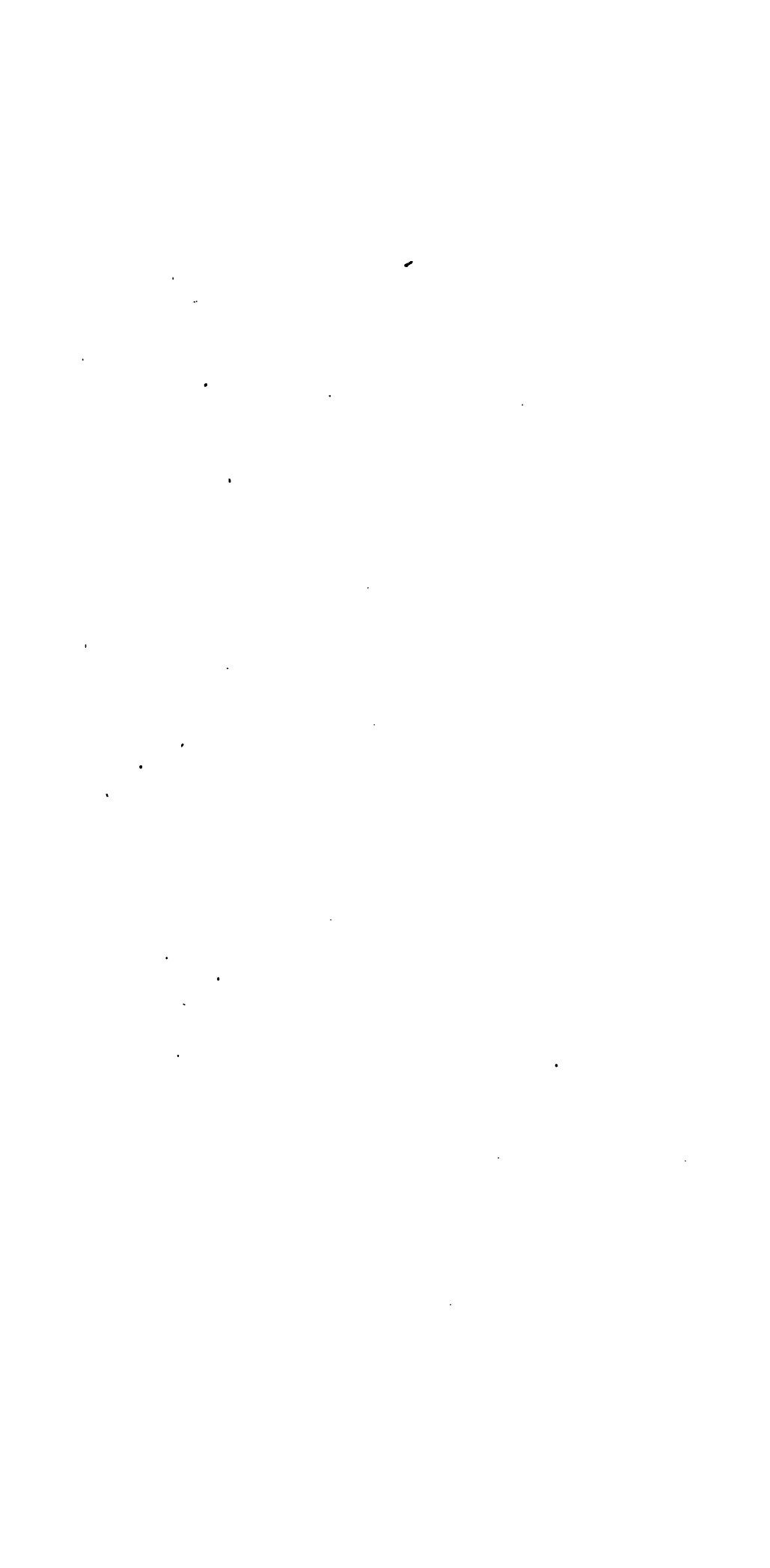
THE SECOND EDITION,
GREATLY ENLARGED AND IMPROVED, BY THE
ADDITION OF THE MODERN DISCOVERIES; AND
BY A NEW ARRANGEMENT OF THE ARTICLES

By JOHN HYACINTH DE MAGELLAN,
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MIARUM IMP. SCIENTIAR. PETROPOLIT. ET BRUXELL.
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PHILOS. PHILADEL. HARL. ET MANCHEST. SOCIUS;
ET ACAD. REG. PARIS. SCIENTIAR. CORRESPONDENS.

IN TWO VOLUMES.

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C L A S S III.

Mineral Inflammable Substances.

S E C T. 228. (144.)

Inflammables. *Phlogista Mineralia* [a].

TO this class belong all those subterraneous bodies that are dissoluble in oils, but not in water, which they repel; catch flame in the fire; and are electrical.

It

[a] Under the class of inflammables, are comprized all such minerals as may be destroyed by combustion, upon the application of a strong heat; and which, in proper circumstances, emit flame, during the time of combustion. *Sulphureous metallic ores, pyrites, and even metallic substances,* may be considered as an order belonging to this class, although they require a still higher degree of heat, to drive off their phlogiston. The *diamond* and *plumbago* seem to be also in the same case. This arrangement, however, would occasion that confusion which is meant to be avoided, by the systematic classification given by our Author in Sect. 2. In regard to these two last substances, I have retained the *Diamond* among the precious stones; and the *Plumbago* follow the Sulphure in the present Class. The Mo-

F f lybdena

It is difficult to determine, what constitutes the difference between the purer sorts of this class;

lybdena however, that has been reputed formerly as a species of *plumbago*, later experiments have shewn to be of a metallic nature: and of course, it will be ranged in the last Class, after the Semi-metals.

The Noble Author says, that phlogistic substances are *electric* (*per se*). It has not, however, that I know, been decided, that all *inflamable minerals* are *electric*, or *non-conductors* of electricity; on the contrary Mr. Kirwan affirms, that fossil coal is not an *electric*.

But, what is the constituent principle by which the minerals, belonging to this Class, become *inflamable*? or rather, what is the nature of these *combustible substances*? what is *combustion*, this common phenomenon so repeatedly beheld, and so little understood, from whence these substances take their denomination? Chemists and Philosophers have given various, and so seemingly opposite theories on this very interesting subject, that it would be impardonable not to give a short account of their ideas, chiefly those of the modern ones, in this edition of a work, whose matter is so intimately connected with these chemical disquisitions.

It was taught by former chemists, that the integrant parts of *combustible bodies* were only *beated, burned, and reduced into flame*, by the action of *fire*, according to the quantity and condition of the *phlogiston* they contained. This last is what they called the *inflamable principle*, by means of which *combustion* is performed. But Becher, Boyle, Rey, and several other Chemists, admitted that the concurrence of *air* is absolutely necessary for the effect of *combustion*. As soon as the various kinds of aeriform-substances began to be known by Modern Philosophers, they soon found, that it is that kind of *air*, discovered by the Father of this new and valuable branch of Natural Philosophy, Dr. Priestley, which he calls *dephlogisticated*, and to which some new Nomenclators give the epithets of *pure, vital, air of fire* and *empyreal air*, without the interference of which no combustion can take place. It is computed,

Sect. 228. INFLAMMABLE SUBSTANCES. 435

class; since they all must be tried by fire, in which they all yield the same product; but those

puted, from many good observations, that among the various component parts of the atmosphere, there is about one-fourth ($\frac{3}{4}$ according to Scheele), or, at least, one-fifth part (according to Mr. Cavendish) of this kind of air, contained therein; and from this circumstance it evidently appears, why by blowing on fire, its violence is proportionably increased.

Mr. Macquer says positively, that *phlogiston* is nothing else but the *elementary fire*, combined with combustible bodies; and that the concurrence of *pure air* is absolutely required, for the effect of *combustion*. The manner, however, by which this wonderful, though common, process is really performed, has been the theme of various modern systems.

According to Mr. Lavoisier, *dephlogisticated air* is a compound of two substances intimately combined; one is called by him *oxygene principle*, and the other is the *specific elementary fire*. When *sulphur*, *phosphorus*, *inflammable air*, or any other combustible body is burned, the *oxygene principle* of the *dephlogisticated air*, says he, combines itself with these bodies, to which it has a strong attraction, and forms new compounds of salts and other bodies (See the latter part of note *a* to Sect. 227): At the same time that the *elementary fire* contained in that air, is set loose, and becomes *sensible*, producing *heat* and *flame*, according to circumstances. In this ethiology the fire produced in *Combustion* does not proceed from the burned body, but from the decomposition of the *dephlogisticated air*, in which it is contained in a *latent* or *insensible state*; while its *oxygene principle* combines itself with *sulphur*, *phosphorus*, or *inflammable air*; and forms *vitriolic* and *phosphoric acids*, or *pure water*.

In the same manner it is pretended, in this theory: 1st, That metals are merely simple substances; 2dly, That *metallic calces* are true compounds formed by the *oxygene* part of *pure air*, with the metallic particles; and 3dly, that *pure water* is a similar compound of the same principle, with *inflammable air*. Unhappily, however, it happens that this *oxygene substance* cannot be shewn to our senses: nor is it better

those which in the fire shew their differences by affording

demonstrated, than the *phlogiston* supposed by the great Stahl and his followers. Mr. Fourcroy has proposed another system after Mr. Lavoisier, which seems less objectionable: he says, that *combustible bodies* are those, which have a strong attraction to unite or combine with *pure* or *dephlogisticated* air; and that *combustion* is nothing else but the act of that combination. This assertion is grounded on the following facts: 1st, That a body cannot be burnt without *air*: 2dly, That the purer is this *air*, the more rapid is the *combustion*: 3dly, That in *combustion*, an absorption or waste of *air* is always observed; and 4thly, That the residuum contains often a very sensible quantity of that *pure air*, which it absorbed, and which may sometimes be extracted from it. According to this theory of *combustion*, the objections against the existence of *phlogiston*, which indeed cannot be demonstrated by an immediate indication to our senses, are entirely avoided. But there are so many phenomena in mineralogy, chemistry, and natural philosophy, which cannot be well understood, nor properly accounted for, without admitting *phlogiston* as a substance, to the presence or absence of which they are adequately attributed, that the *phlogistic principle* cannot be exploded, with propriety, from the theoretic part of Chemistry. See the note to the following Section about the existence of *Phlogiston*.

Long before Messieurs Lavoisier and Fourcroy communicated their doctrine of *combustion* to the public, the *Treatise* of Mr. Scheele on *fire* was published, in 1777, at Stockholm, in which this great Chemist discloses his new system on *fire*, *heat*, *light*, and *phlogiston*; these he represents, in such a striking manner, as being different substances, though nearly related to one another, that we should hardly refuse our conviction to his inductions, were they generally supported by facts, and more consonant to our former ideas on a subject so little perceivable by our senses. *Heat*, according to this able Chemist, is a *compound substance*, consisting of *phlogiston* and *empyrean air*. The calces of gold, which can be reduced to a metallic form, by *heat* alone, in a retort, shew that *phlogiston* is contained in *heat*: because it combines with the calces to
revive

fording different substances, are here considered as
being

revive them, and the *dephlogisticated* air is found in the receiver. The precipitate *per se* of Mercury, if revived in the same manner, gives another instance of this truth. If phlogiston alone, says he, could pass through the retort, there would not be found the *empyreol* air in the receiver, and the ignoble metals might be also revived in the same manner.

I do not see, I must confess, that Mr. Scheele has pointed out any reason, why the *ignoble metals* should not be reduced or revived likewise, from their calces, by the *phlogiston*, contained in the *beat* that passes through the retort; and as to the *dephlogisticated* air he speaks of, which is found after the reduction of those *noble metals*, it may have been combined with their calces, before they were put into the retort. Mr. Kirwan, in his Notes to this *Treatise on Fire*, from which this summary view is taken, says, 1st, that in no instance does it appear that phlogiston penetrates through glass, much less a compound of *pure air* and *phlogiston*; and 2dly, that if Mr. Scheele's notions were true, then other metallic calces, or at least black manganese, would be reduced by bare heat; for this calx dephlogisticates nitrous acid, and therefore has a stronger affinity with *phlogiston* than this acid, as Bergman affirms: *beat* therefore ought as well to be *decomposed* by it, as by nitrous acid. This last objection can hardly be answerable but by some unknown property of the manganese, which is no answer at all. But in regard to the first, many combinations are known of two or more substances that pass through bodies, which would stop each before they were combined; and what Mr. Scheele has said on the nature of *light*, seems to prove, that glass is not always quite impervious to *phlogiston*.

Light, according to Scheele, is a compound, containing *phlogiston* and *beat*, from which both may separate themselves in proper circumstances. A solution of silver, by *nitrous acid*, mixed with *chalk*, and exposed to the sun-shine, is revived into a metallic form by the phlogiston of *light*. Nitrous acid also in a glass vessel, receives *phlogiston* from *light*, and becomes of an orange colour; but if the glass be painted black,

being mixed with heterogeneous bodies : that
small

the acid receives the *heat*, not the *phlogiston*. Even the various coloured rays of light contain unequal shares of phlogiston, since the *violet rays* part more easily with their *phlogiston*, than the other rays, to revive metals. When light is not obstructed in its passage, no heat is perceived ; but if stopped in its course, the opposing body receives *heat*, and sometimes *phlogiston*. Light seems therefore to be the matter of *heat* loaded with a superabundant quantity of *phlogiston*. That which comes out from a furnace, produces *heat* on the surrounding bodies, which ascends up with the rarified air : proceeds forwards in straight lines : and may be reflected from polished surfaces, with this peculiarity, that a concave glass-mirror retains the *heat*, whilst it reflects the light ; for, although its focus is bright, yet it is not warm. A plane of glass interposed to this light, retains the *heat*, and becomes *hot*, but lets the light pass through.

Fire is the more or less *heated*, and more or less *luminous* state of bodies, by which they are resolved into their constituent parts, and entirely destroyed. It requires that they be previously *heated* in contact with air ; for, to every *combustible body*, a certain quantity of *heat* must be communicated, in order to set it in the fiery commotion.

Combustion is the action of the *heat* penetrating the pores of bodies, and destroying their cohesion ; in this case the body parts with its phlogiston, provided there be a substance present, which has a strong attraction to the inflammable principle. If the heating be performed in open air, the *empyreal air* (which makes one-fourth part of the bulk of the atmosphere), on account of its stronger attraction, unites with the *inflammable principle*, which is thus set at liberty ; from this union the *heat* is compounded ; and scarcely is this heat generated, when the combustible body is still more expanded by it than in the beginning, and its phlogiston more laid open. The more the heat is increased, the more minute are the particles into which the *combustible body* is dissolved. The *empyreal air* meets more surfaces, consequently comes in contact with more *phlogiston* ; and, according to its nature,

small quantity of earthy substance, which all
phlogista

ture, forms an union with a greater quantity of it, which causes a radiant heat. At this moment the constituent parts of the combustible body are so much disunited by the still increasing heat, that the empyreal air, continuing to pour upon it in streams, attracts the phlogiston in still greater quantities; and hence the most elastic substance, *Light*, is composed, which, according to the quantity of *combustible matters*, shows various colours,

Such is the abstract of Scheele's new system, taken from that given by Mr. Ruffel, in his Notes to *Fourcroy's Lectures of Chemistry*, which I compared with the original French translation of the Author, as it is more correct than the English translation of J. R. Foster; and it appeared to me perfectly consonant to the author's ideas. But the only system that I know, which fully and satisfactorily develops these obscure matters, relating to the nature of *combustible* and *phlogistic processes*, is that given to the public by Dr. Adair Crawford, whose friendship I shall always acknowledge with the highest pleasure. His New Theory was completed, and put in the hands of the public, before either he, or any other person in England, had the least knowledge of Mr. Scheele's doctrine. I published, in the year 1780, a *small essay* on this subject, containing a sketch of Dr. Crawford's doctrine, reduced into a mathematical form, which is mentioned by the late famous Professor Bergman, in his excellent treatise *de Attractionibus electricis*, and was inserted in *Journal de Physique*, for May and June, 1781. The following sketch of the part relating to *combustibles*, is the only one that can be allowed to this note.

Dr. Crawford discovered, by the most accurate and nice experiments, that bodies, which contain a large portion of *phlogiston*, possess but a small share of *specific heat* or *fire*; on the contrary, that those with a great share of this last, contain but little *phlogiston*; and finally, those which are deprived of *phlogiston*, increase their capacity for a greater share of *specific fire*. Thus, when regulus of antimony is deprived of its phlogiston, by calcination, which is then called *diaphoretic*,

phlogista leave behind in the fire, is not, however, attended to.

SECT.

retic, it nearly triples its *specific fire*. The same change takes place in the *crocus martis* and in *iron*. This fact is generally true, whatever be the nature of the substance; and even the aeriform ones are in the same case; for phlogisticated air has very little *specific fire*: common air has more of it; and *dephlogisticated* air shews a most prodigious quantity of *fire*.

From these facts it is clear, that *phlogiston* and *fire* are distinct and incompatible substances; so that when one enters into the composition of any body, the other of course is expelled from it. Thus metals are calcined in consequence of a double attraction, by which the metal imparts its *phlogiston* to the air, while the air communicates its *fire* to the metallic calces; which is further confirmed by the *air* that is found in metallic calces, whose increased weight, by calcination, corresponds to the *air*, that is expelled from them, by their reduction to a metallic form.

All *combustible* bodies are absolutely in the same case. These are substances which contain a large quantity of *phlogiston* in their composition, but loosely adherent to them. *Dephlogisticated air*, which is greatly loaded with *specific fire*, has, at the same time, a strong attraction to *phlogiston*; and, in the act of *combustion*, imparts its *fire* to the *combustible body*, which is consumed, whilst the air becomes phlogisticated, or loaded with *phlogiston*. Thus we find that sulphur contaminates the air, when burned, by the *phlogiston* it throws into it, and the produced vitriolic acid, if any, becomes impregnated with the same.

In some cases the most intense heat, or sensible fire, is produced in the combustion; but in others it is very moderate. This variety generally depends from the quantity and quality of the vapours produced by the combustion; when these are very inconsiderable, and the residuum cannot absorb the *fire*, which is emitted by the air, the remainder is precipitated or diffused all around, and produces a very sensible heat. On the contrary, if the vapours are capable of absorbing it, then very little heat is produced. We know by the most cer-

tain

S E C T. 229. (Additional.)

Inflammable Air. Fire Damp. *Aer Inflammabilis.*

This aeriform substance is easily known by its property of inflaming, when mixed with twice or thrice its bulk of common atmospheric air; and it may be safely asserted to be the real phlogiston almost pure [a].

It

tain experiments, that, for instance, the vapour of water absorbs about 800 degrees of heat beyond that of its boiling state; from whence it follows, that whenever there is a quantity of watery vapours produced by combustion, very little sensible fire must be felt. So when spirits of wine are fired, the sensible heat, which results from the combustion, is very inconsiderable, as the greatest part is absorbed by the watery vapours that are then produced; but when the phosphorus of Lunkel catches fire, the heat is very strong, there being but a small quantity of acid to carry off the specific fire that is set loose. This is the most satisfactory theory of the nature and process of combustible bodies, and of their combustion, so far as the state of our present knowledge has opened the field of our views into the Operations of Nature. *The Editor.*

[a] The late eminent Philosopher, Professor Bergman, speaking of phlogiston, in his admirable Treatise upon Elective Attractions, says, that "the inflammable air extracted from metals, contains phlogiston almost pure; and that the two celebrated Philosophers, Priestley and Kirwan, seem to have clearly proved the existence of phlogiston, both analytically and synthetically: so that, according to him (this last named gentleman), all reasons for doubting are now removed. This phlogistic principle, when in combination, may be let loose by various methods: having recovered its elasticity, and gained an aerial form, by a proper addition of specific heat,

It is naturally found in subterraneous cavities, in some coal-pits, and other mines; in stagnant waters, in the mud of lakes [4], and other

it receives the name of *inflammable air*." But some French Philosophers, at the head of whom is the famous Mr. Lavoisier, pretend, that there does not exist such a being in Nature, as that called, since the time of Becher and Stahl, by the name of *phlogiston*.

They say that the absorption, or combination of *dephlogistified air*, with metallic bodies, by the help of fire, and its expulsion or separation from their calces by the same agent, is all that is required both for their *calcrnation*, and for their *reduction* or *revivification*. But there is a vicious circle in this new theory, which easily evinces the fallacy of their argument against the existence of phlogiston. If it be owing to fire, that *pure*, or *dephlogistified air*, combines with metals to reduce them to the state of *calces*, why do all metallic calces (those of *gold* and *mercury* excepted) require any *phlogistic* or *inflammable substance* to reduce them back to their metallic form? If not, it should naturally follow that the simple expulsion of pure air by fire, without any phlogistic matter being made use of, ought to be fully sufficient to effect that revivification. Monsieur de la Metherie, in a letter inserted in the latter part of the *Journal de Physique*, for June 1784, p. 473, has produced various and strong reasons against these new, but feeble, attempts for exploding the existence of Phlogiston; and Mr. Kirwan is now collecting the most convincing facts to set this truth in the most clear light. See what has been said in the Note to the last Sect. on this subject.

The Editor.

[4] Mr. Volta, professor in the University at Pavia, has discovered a kind of *inflammable air*, which is very common in Nature, and is found in the mud of various ponds and rivulets. When a stick is thrust into the mud of such places, the air rushes up in large bubbles; and may be easily collected by a funnel, held fast by a metallic ring, into the mouth of an inverted glass vessel filled with water, at the end of a stick; in the same manner as Dr. Pearson has proposed to get the medicinal gas of the Buxton water. This kind of inflammable air seems

other places, where animal and vegetable substances have undergone putrefaction, as lay-stals, old privies, &c. Also on the surface of springs in Persia, Italy, and France, where it seems to be nothing else but the exhalation of petrol.

It is found likewise over the surface of the earth in various places. The *ignis fatuus*, or *jack-lanterns*, as well as different fiery meteors, owe their existence to this substance; and the *falling stars* seem to be nothing else but so many trains of inflammable air, in the superior parts of the atmosphere, which catching fire by electricity or otherwise, produce that appearance by burning downwards; as is rendered very probable, by the hissing noise that is sometimes very audible at their appearance.

Inflammable air is also artificially produced in great abundance, by the dissolution of iron or zinc, in almost all known acids (the *nitrous* excepted); by digesting iron in an infusion of galls; by dissolving zinc in the mineral alkali; by combining iron and zinc with volatil alkali; by the calcination of these two metallic sub-

seems to be the usual produce of the putrefaction, and complete decomposition of vegetable substances in water. Its inflammability is greater or more intense than that of *inflammable air*, produced from the solution of iron or zinc in the *vitriolic* acid; for it requires to be mixed with a larger portion of atmospheric air, to produce its greatest explosion by the flame of a candle. Dr. Priestley mentions this discovery of Professor Volta, in his 3d vol. on *various kinds of air*: and Mr. Volta has published, afterwards, a Treatise on this subject in Italian, with an account of his discovery, &c. Editor.

stances

stances in the fire: and Mr. Kirwan found lately, that an amalgam, made of zinc and mercury, in a close vessel, after both had been previously dried in a sufficiently strong, and long continued heat, produced a good quantity of *inflammable air*; so that the boasted theory of some French philosophers, who pretend that some water is essentially necessary for the production of *inflammable air*, is evidently false [c].

Oils,

[c] When inflammable air and dephlogisticated air are burned together, water is found to be the residuum, as Mr. Volta, many years ago, found often in the experiments made with his new Eudiometer. Mess. Cavendish, Lavoisier, Monge, La Place, and Meusnier, have ascertained this fact; and that the weight of this water, so produced, is nearly the same as that of the two burned airs. But neither of these gentlemen ever purified the *inflammable* and *dephlogisticated* air, from the watery vapours they contain: it is these last, as it seems, which produce that water, they find afterwards.

Mr. Cavendish says, that *pure* or *dephlogisticated* air, is water deprived of its phlogiston; and that *water* is *pure air* united with phlogiston. But Mr. Watt thinks that water is composed of *dephlogisticated* air, and *phlogiston*, deprived of great part of its *elementary fire*; and that dephlogisticated air is *water* united to a great quantity of *elementary fire*, and deprived of its phlogiston.

Mr. Lavoisier asserts, that water is a combination of *pure* and *inflammable air*; so that 8686 parts of the first, with 1314 of inflammable air, makes 10,000 of water; and that this *inflammable air* is 12 times lighter than *common air*.

But Mr. de la Metherie holds on the contrary, that the water produced by the combustion of these two airs, is contained in them both. The experiments of the hygrometer, and the deliquescence of salts, prove, beyond all doubt, that air contains a considerable quantity of water: and we know that the mixture of *pure* and *nitrous* air produces *nitrous acid*, which is as *fluid* as water; so that *dephlogisticated air* evidently contains

Sect. 229. INFLAMMABLE SUBSTANCES. 445

Oils, bitumens, and charcoal, distilled dry in a retort, or by their digestion on the fire; lime, and even powder of pebbles, digested in the same manner with *marine acid*, or with *marine acid air*, produce also this inflammable substance. Its principal properties are as follow :

1. It is the lightest of all aeriform substances; viz. 10, or even more times lighter than common air. Mr. Kirwan collected it very slowly over quick-silver; and found it then 12 times lighter than atmospheric air. On this account, inflammable air has been employed in the new invented aerostates, by the help of which various adventurers have performed aerial voyages with success. But that inflammable vapour, which is formed from vitriolic air, is heavier than common air.
2. It cannot be inflamed without the concurrence of atmospheric air; but when mixed with it, in a due proportion, and set on fire, it explodes with a considerable noise. If the mixture be of *dephlogisticated air*, a detonation is produced as loud, as the report of a pistol [*a*]; but mixed, or combined

tains this fluid in itself; and the experiment of Mr. Kirwan, mentioned above in the text, is a demonstration that there is not need of any water or moisture for the production of *inflammable air*. The Editor.

[*d*] Inflammable air, on account of its elastic nature, and of its levity, expands itself over a wide space, and may have every particle contiguous to a sufficient quantity of the *dephlogisticated*

#46 INFLAMMABLE SUBSTANCES. Sect. 229.

combined with *fixt air*, it burns with a blue lambent flame.

3. The flame of a candle, a burning coal, an electric spark, and that produced by the stroke of a flint, with steel, sets it on fire. From whence it is evident, that the idea of employing this last kind of light, in those mines where inflammable air happens to be found, is erroneous; though, as it always occupies the higher part of the subterraneous cavities, on account of its levity, it may happen sometimes to escape the action of the fire.
4. When unmixed and pure, it extinguishes fire.
5. If breathed, it kills animals. Those who pretended to breathe it with impunity, did not previously breathe out, from their lungs, the whole of the common air, that there was before.
6. It has a disagreeable smell, when extracted from metals; if over mercury, the smell is better. That which is found in marshes, smells musty.
7. It is not absorbed by water, at least that which is extracted from metals, over which it may be kept a long time without alteration; but after one or two years, it is no more inflammable.

phlogisticated air mixed with. In this situation a spark of fire pervades the whole mass at once, and produces that violent explosion. *Editor, from Ruffel's notes.*

8. Does

SECT. 229. INFLAMMABLE SUBSTANCES. 447

8. Does not render lime-water turbid by itself; but being inflamed over it, the water is troubled, and deposits some of the chalk it contains.
9. Has no acid qualities.
10. Does not calcine metals; on the contrary, Dr. Priestley has revived some of their calces by the rays of the sun, through a burning lens, in a glass vessel filled with this air, over a basin of mercury.
11. It accelerates vegetation.
12. It hinders putrefaction, though in a degree very inferior to fixed air.
13. It is absorbed by charcoal [e].

Editor, chiefly from Leonhardi, Kirwan, &c.

SECT.

[e] Inflammable air admits considerable varieties, according to the nature of the substances from which it is produced, and often gives different residuums upon combustion, some of which are of the acid kind. If it is produced from charcoal, it yields *aerial acid*, or *fixt air*: from solutions of metallic substances in the *vitriolic*, *nitrous*, or *marine acids*, it yields these respective acids, as Mr. Lavoisier asserts.

Æther, converted into vapour in a vacuum, gives a permanent elastic vapour, which is *inflammable*. The atmosphere, which floats round the *Fraxinella* (the plant called *diâflame blanc*, which grows in the woods of *Languedoc*, *Provence*, *Italy*, &c.) is inflammable from the admixture of its vapours, which seem to be of the nature of an essential oil: so that on approaching the flame of a candle under this plant, in hot weather, it takes fire in an instant; although the essential oil, extracted from this plant by distillation, is not inflammable, on account of the watery particles mixed with it, as Mr. Bomare asserts.

Mr. Scheele is of opinion, that every inflammable air is composed of a very subtile oil. This coincides with the idea entertained

S E C T. 230. (Additional.)

Hepatic Air.

This air seems to consist of sulphur, held in solution, in vitriolic or marine air. It is inflammable, when mixed with three quarters of its bulk of common air. Nitre will take up about half the bulk of this air : and when saturated with it, will turn silver black ; but if strong dephlogisticated nitrous acid be dropped into this water, the sulphur will be precipitated [a].

One

entertained, by chymists, of their phlogiston ; and is confirmed by the fact, of its being naturally found in those springs from whence issues petrol, whose exhalations are very inflammable.

The residuum, which remains in the atmosphere after the combustion of inflammable air, is extremely noxious to animals. Doctor Priestley takes it to be a combination of *phlogiston* with *pure air*, and, on this account, calls it *phlogisticated air*. But Mr. Lavoisier, on the contrary, thinks this to be a *primitive substance* of an unchangeable nature, and gives it the singular name of *atmospheric mephitic*. The Editor.

[a] The great Swedish Chemist Mr. Scheele, was the first who discovered the existence of this kind of air ; and although his Treatise on *Air and Fire* has been published since the year 1777, hardly any other philosopher has carefully examined its singular properties. Mr. Kirwan has, however, applied himself of late to this object ; and has communicated to the Royal Society, his various and interesting observations upon it ; as these were made on vessels over quicksilver, we may depend on the results, because, if the vessels are over water, this air is in great part absorbed by it ; and for this circumstance

One hundred cubic inches of this-air, may hold eight grains of sulphur in solution, in the temperature of 60°; and more, if hotter.

Atmospheric air also decomposes hepatic air.

It is found in many mineral waters, and particularly in the hot baths of Aix-la-Chapelle.
The

circumstance these results are sometimes different from those of Mr. Senebier, who has wrote on the same subject.

Professor Leonhardy, in his Treatise upon the *Discoveries of various Airs*, points out the most part of the following properties of *hepatic air*.

1. Its smell distinguishes it from any other kind of air, being like the smell of rotten eggs, or the smell of *hepar sulphuris*.
2. Mixed with two-thirds of common or nitrous air, it may be set on fire by the flame of a candle, like the *inflammable air* of the last Section; the vessel is filled with a white thick smoke, which smells like volatil spirit of sulphur; and a white powder is deposited, which consists of sulphur. It detonates with *dephlogisticated air*.
3. It is miscible with water, and communicates to it a flat, but penetrating and very disagreeable flavour.
4. It kills animals, if inclosed therein.
5. It extinguishes also the flame of a candle when immersed in it.
6. Does not change the colour of paper tinged with Fernanbuco wood:
7. But it always turns the tincture of turnsol to red, whatever be the manner by which it had been produced.
8. Mixed with atmospheric air, it phlogisticates it.
9. The vitriolic, marine, and acetous acid, do not precipitate the sulphur from it. But
10. Nitrous acid, and dephlogisticated marine acid, do precipitate the sulphur from it.
11. Tin, bismuth, regulus of antimony, and zinc, are not attacked by this air.

450 INFLAMMABLE SUBSTANCES. Sect. 230.

The cause and manner of their containing sulphur, which was long a problem, has at last been happily explained by Mr. Bergman.

It plentifully occurs in the neighbourhood of volcanos, and in several mines. *Kirwan.*

12. But copper and iron become of a blue colour; lead easily tarnishes, when immersed in it; and mercury becomes black.
13. Water, impregnated with hepatic air, turns silver black; precipitates arsenic, from its solvent, into a powder resembling orpiment: precipitates zinc from the vitriolic acid: and the solution of corrosive sublimate, into a white powder. The solutions of silver in nitrous acid and of salt of lead, are precipitated of a black colour. The solution of copper, and of the martial vitriol, as well as that of mercury in nitrous acid, are precipitated by the same, of a dark brown colour.
14. This water, so impregnated, dissolves iron filings; and this solution takes a purple colour, if the infusion of galls be added to it. But phlogisticated alkali does not produce any change.
15. It does not precipitate lime from lime-water, unless a very large quantity of this air passes through a small one of water.

Hepatic air is easily obtained by art, from all sorts of liver of sulphur, whether the base be an alkali, an earth, or a metal, if any acid is poured upon it: and the better, if use is made of the marine acid, because it contains phlogiston enough, and does not so strongly attract that of the *hepar sulphuris*. For this reason the nitrous acid is not fit for this process, as it combines itself with the phlogiston, and produces *nitrous air*. It may also be produced, by distilling a mixture of *sulphur* and *powdered charcoal*; or of sulphur and oil, &c.

According to Mr. Kirwan (in the first part of *Phil. Trans.* for 1786), *hepatic air* consists of *sulphur* alone, kept in an aerial state by the *matter of heat*. It has evidently, though weakly, an acidity of the *vitriolic kind*, as sulphur does; and no *inflammable air* can be extracted from it, unless when produced by those compounds, which afford the same, as *carbonaceous*, and *saccharine compounds*, &c. *The Editor.*

S E C T.

S E C T. 231. (154)

Phlogiston combined with Aerial Acid. Black Lead, or Wadd. Phlogiston acido aereo satiatum. Plumbago, Lat. Reisbley, Germ. Blyertz, Swed. [a].

..... It is found

b. Of a steel-grained and dull texture, *textura chalybea*. It is naturally black; but when rubbed, it gives a dark lead-colour.

c. Of

[a] The Author, and all preceding Mineralogists, confounded the *black lead* with *molybdena*, whose appearance is nearly the same; although, on close examination, the texture of the last, which is composed of very distinct oblong scales, easily distinguishes it from the *black lead*. This last substance, having been lately found to be of a metallic nature, will be ranged among the *Semi-metals* in the fourth and last Class of Minerals.

The black-lead, or plumbago, is a fossil substance extremely black; but when fresh cut it appears of a bluish white, and shining as lead.

Its texture is micaceous, and minutely scaly; pretty brittle; and, when broken, of a granular and dull appearance.

It leaves a fine blackish, smooth, and shining trace, when rubbed on paper; but of a much darker hue than that made with molybdene, which has a white silvery appearance. This easily distinguishes one from the other.

Black-lead is too soft to strike fire with steel.

c. Of a fine scaly and coarse-grained texture, *textura micacea et granulata*. Coarse black-lead.

It has

Its specific gravity is from 1,987 to 2,267. Briffon found it to be = 2,1456.

Is insoluble in the mineral acids.

In a strong heat and open fire it is wholly volatile, leaving only a little *iron*, which seems to be accidentally found in it, and a few grains of siliceous earth.

The usual fluxes do not effect its fusion.

It is decomposed by detonation with nitre, in a red hot crucible.

Mr. Scheele found that plumbago consists of phlogiston combined with *aerial acid*. But Mr. Pelletier has demonstrated, that, when it is pure, it neither produces any *fixed* or *inflammable air*; both which, when found, are entirely owing to the substances that are mixed with it.

One part of *plumbago*, according to Mr. Scheele, requires ten of nitre to decompose it, whereas one of *charcoal* requires five of nitre; hence it appears to contain twice as much phlogiston as charcoal does.

From hence Mr. Kirwan deduces, that 100 parts of plumbago contain 67 of phlogiston; for 100 gr. of nitre contain 33 gr. of real *nitrous acid*; these are decomposed, when it receives as much phlogiston as is necessary to convert it into *nitrous acid*, or a little more. Now 33 gr. of nitrous acid are converted into *nitrous air* by 67 gr. of phlogiston; then 100 gr. of nitre require, for their decomposition, 67 gr. of phlogiston. The remaining 33 parts may be water, or other volatile substance. For, according to Messieurs Gahn and Hielm, 100 gr. of plumbago, calcined in a muffle, did lose 90 gr. in weight, the remainder was a ferruginous earth; and the sulphureous smell shewed it contained some pyrite, which both were accidental to the black-lead. But Mr. Pelletier affirms, that this substance is volatilized in a strong fire, without producing any air, nor other aeriform substance: from whence it

It has at the same time a scaly and a granulated appearance.

From

it must be concluded, that the plumbago analysed by Mr. Scheele, was not quite pure.

But when this substance is exposed in close vessels, it undergoes a long and strong heat, as charcoal does, without any loss in its weight,

Our Author (Cronstedt), has observed, in a note to this Section, that "Professor Pott had examined the black lead in covered vessels, and Mr. Quist, in an open fire: from which difference in the method of treating it, different notions have arisen: because the black-lead is nearly unalterable when exposed to the fire in covered vessels, or when immediately put into a strong charcoal fire, but it is almost wholly volatile in a calcining heat. This is the case with several others of the mineral phlogistons; and from this we may in general learn, how necessary it is to examine the mineral bodies by many and different methods; and to endeavour to multiply the experiments more, than what has been hitherto done."

Mr. Pelletier asserts, that metallic calces cannot be reduced with it alone, unless mixed with *fixed alkali*, in the same manner as when charcoal is employed in such circumstances.

Nor can it be combined with iron, as Bergman asserts, or with any other metal, although it may be simply interspersed between its particles.

Mr. Pelletier acknowledges, that there is a kind of plumbago found swimming over the melted iron in large furnaces, where iron-ores are smelted. But he thinks that this must have been naturally mixed with the mineral; and it is the only known plumbago of a very distinct lamellar form, as he observed in the pieces got from the iron-works at Valancy, in the French Province of Berry.

This singular fossil was classed also among the *inflammables* by Professor Bergman, in his *Sciagraphia*, as well as the *diamond*, on account of their burning in a vehement fire, without leaving any residuum. Mr. Kirwan, in his excellent *Elements of Mineralogy*, thought they both

From Gran in the province of Upland, and from Tavastehuslan in Finland [b].

SECT.

deserved to be treated separately from any other class of fossil substances, on account of their combustion commencing at so high a degree of heat; but I thought proper to preserve them both, in the classes where our Author had put them at first, as was already mentioned, Note a, page 433.

[b] Black-lead is found in various parts of the world, though sparingly, and of very different qualities; viz. in *Germany, France, Spain, Cape of Good Hope, and America*; but the best sort, which by its fine black and shining substance, is the fittest of all for making good pencils to draw upon paper, is only found in the County of *Cumberland*, in England, at a place called *Borrowdale*, which may be said to furnish the whole continent abroad, as well as at home, with this useful mineral. I have seen various specimens from different countries, but their coarse texture and bad quality, cannot bear any comparison with that of *Borrowdale*, though it sometimes, but seldom, contains pyritaceous particles of iron, &c. It is but a few years ago that this mine seemed to be almost exhausted; but by digging some few yards through the strata underneath, according to the advice of an experienced Miner, whose opinion had been long unattended to, a very thick and rich vein of the best black-lead has been discovered, to the great joy of the proprietors, and advantage of the public.

The great use of plumbago, is to draw the out-lines and sketches of any figure on paper, in the most easy and expeditious manner; and it has the advantage of being taken off at pleasure, by rubbing it off entirely with a piece of that elastic gum or resinous substance, which comes chiefly from Brazil, called by the natives *Caout-chouc*, and known in England, (not many years ago, for this use) by the name of *Indian-rubber*. See the following Sect. 238. on the elastic Petrol.

The plumbago is adapted for this purpose, by being cut into thin parallelpipeds, and put in quadrangular grooves made of cypress-wood; and a slit being glued over, they are worked into small cylinders like quills. This is the true method

S E C T. 232. (Additional.)

Mineral tallow. *Sevum minerale. Mumia*, Lat.
Beleffoon.

This was found in the sea on the coasts of Finland, in the year 1736. Its specific gravity is 0,770; whereas that of tallow is 0,969. It burns with a blue flame, and a smell of greafe, leaving a black viscid matter, which is with more difficulty consumed.

method by which the good English pencils are made; whereas the method, indicated by Mr. Fourcroy, of employing the powder of this mineral, made into a paste with sulphur, or mixed with some mucillagenous substance, is never employed but by some poor Jews, who sell these pencils very cheap for carpenters work, and other coarse drawings.

One part of plumbago, with three of clay, and some cows hair, makes an excellent plaster for covering retorts in chemical laboratories, as it keeps the same form, even after they happen to melt with the force of fire.

The famous crucibles of Ypsen, are made at Passlaw, in Saxony, with plumbago mixed with clay: they are known in England by the name of *Hessian crucibles*; but there is now a manufactory of the same kind at Chelsea, near London, where crucibles are made nearly as good as the foreign ones. The powder of *black-lead* serves also to cover the straps of razors; and it is with it, that cast-iron work, as stoves and the like, receive a shining surface; but an useful application of this stuff, not generally known, is to smooth the surfaces of wood-work, which slide one over the other, such as *wooden-crews*, *packers-presses*, &c. as neither greasy nor oily substances, or any kind of soapy ointments, produce so good an effect on them. *The Editor*.

G g 4

It

456 INFLAMMABLE SUBSTANCES. Sect. 232.

It is soluble in spirit of wine, only when tartarized: and even then leaves an insoluble residuum; but expressed oils dissolve it when boiling.

It is also found in some rocky parts of Persia, but seems mixed with Petrol, and is there called *Schebennaad*, *Tsienpen*, *Kodreti*.

Mr. Herman, a physician of Strasburg, mentions a spring in the neighbourhood of that city, which contains a substance of this sort diffused through it, which separates on ebullition, and may then be collected.

Thus far Mr. Kirwan, who, with great propriety, inserted this substance in his *Elements of Mineralogy*, among Phlogistic Minerals; but Dr. Lippert was doubtful whether this substance could be classed amongst them, though he has not given any good reason for excluding it.

But that there exists a fat mineral, like *tallow* or *butter*, has been lately proved by the extraction of a greasy substance out of peat in Lancashire, as will be mentioned in Sect. 250. *The Editor*.

SECT.

S E C T. 233. (145.)

Ambergris. *Ambra grisea.*

It is commonly reckoned to belong to the mineral kingdom, although it is said to have doubtful marks of its origin [a].

a. It

[a] Ambergrise, according to the assertion of Mr. Aublet, (in his *Histoire de la Guyane*, printed in 1774), is nothing more than the juice of a tree inspissated by evaporation into a concrete form. This tree grows in Guyana, and is called *Cuma*, but has not been investigated by other botanists. When some branches are broken by high winds, a large quantity of the juice comes out: and, if it chances to have time to dry, various masses (some of which had been so large, as to weigh 1200 pounds and more), are carried into the rivers by heavy rains, and through them into the sea: afterwards they are either thrown into the shore, or eaten by some fish, chiefly the spermaceti-whale, known by the name of *Physeter-Microcephalus*, among Ichthyologists. This kind of whale is very greedy of this gum-refin, and swallows such large quantities, when it meets with it, that they generally become sick; so that those employed in the fishery of these whales, always expect to find some amber, mixed with the excrements and remains of other food, in the bowels of those whales, who are lean. Various authors, among whom is Father Santos, in his *Ethiopia Oriental*, who travelled to various places of the African coast, and Bomare, say, that some species of birds are fond of eating this substance, as well as the whales and other fishes. This accounts very well for the *claws, beaks, bones, and feathers* of birds; parts of *vegetables; shells* and *bones of fish*, and particularly for the *beaks* of the *cuttle fish*, or *sepia octopodia*, that are sometimes found in the mass of this substance. Dr. Swedjar, however, attended only to these last, though

- a. It has an agreeable smell, chiefly when burnt :
- b. Is consumed in an open fire :
- c. Softens in a slight degree of warmth, so as to stick to the teeth, like pitch.
- d. It is of a black or grey colour ; and of a dull or fine grained texture [b].

The

though he had mentioned also the other substances in his paper, inserted in the *Philosophical Transactions* for 1783, wherein he attempts to establish the very erroneous opinion, that the amber is nothing else but a preter-naturally hardened dung, or faeces of the *physeter whale*. It is not a little surprising, that both Dr. Withering and Mr. Kirwan have embraced this ill-grounded notion. Certainly they did not read that paper with any sort of attention, or they would have perceived the futility of his reasoning.

[b] The late Mr. Aublet abovementioned, with whom I was intimately acquainted, gave me some specimens of this gum-resin, which he collected, on the spot, from the *cama tree*, at Guyana. The best of these I presented to my late worthy friend Dr. Fothergill, who, for the eminent qualities of his mind, and the benevolence of his heart, will be ever regretted by all that knew him. From the remainder of these specimens, I gave the best to my worthy friend Dr. Combe, F. R. S. : and the rest I still keep. It is of a whitish brown colour, with a yellowish shade ; it melts and burns like wax on the fire, but it is rather of a more powdery consistency than any amber I have seen, probably on account of the improper season in which it was collected. The singularity of this gum-resin is, that it imbibes very strongly the smell of the aromatic substances which surround it ; and it is well known, that perfumers avail themselves very considerably of this advantage. My late friend, Mr. Rouelle, one of the greatest chemists of France, examined very carefully, this substance brought over by Mr. Aublet : and found that it produced the very same results as any other good kind of amber. Besides Mr. Aublet's authority, which is decisive, as being grounded

The grey is reckoned the best, and is sold very dear. This drug is brought to Europe from the Indies. It is employed in medicine: and also as a perfume [c].

grounded upon direct proofs of fact, Rumphius, quoted by Bergman, long since mentioned a tree, called *Nanarium*, whose inspissated juice resembles amber. It cannot therefore at present be doubted that the origin of this phlogistic substance is the vegetable kingdom; although it may be often found and reputed, as a product of the fossil kind.

This substance, being analysed by Messrs. Geoffroy and Newman, quoted by Mr. Fourcroy, yielded them the same principles, as the bitumens; viz. an acid spirit, a concrete acid salt, some oil, and a charry residuum; which evidently evinces, I think, that all these fat and oily fossil substances, have their origin from the other two kingdoms of Nature. *The Editor.*

[c] Ambergrise is not only brought from the East Indies, but from the coasts of the Bahama Islands, Brasil, Madagascar, Africa, China, Japan, the Molucca Islands, the coasts of Coromandel, Sumatra, &c. Dr. Lippert, in the Treatise he published at Vienna, in 1782, entitled *Phlogistologia Mineralis*, has copied chiefly from Wallerius what he asserts of this substance. He affirms that there are eight known species of amber, five of a single colour; viz. the white and the black from the Island of Nicobar, in the Gulph of Bengal, the ash coloured, the yellow, and the blackish; and two variegated; viz. the grey coloured with black specks, and the grey with yellow specks. This last he asserts to be the most esteemed on account of its very fragrant smell, and to come from the South coast of Africa and Madagascar, as well as from Sumatra; and that the black dark coloured amber is often found in the bowels of the cetaceous fishes. The same author adds also from Wallerius, that by distilling the oil of yellow amber (succinum) with three parts and a half of fuming nitrous acid, a residuum remains like rosin, which emits a perfect smell of musk; from whence some conclude, that the ambergrise belongs to the fossil kind: the contrary, however, is evinced in the preceding Note. *The Editor.*

S E C T. 234. (146.)

Amber. *Ambr. frus. Sacchar. Electrum:*
Lat. *Carab.*, French. *Argée, Bernstein,*
Gene.

This is a substance which is dug out of the earth, and found on the sea-coasts. According to the experiments of Mr. Brunckin, it consists of an inflammable substance, united with the acid of common salt, which seems to have given it its hardness &c.

It

[a] The yellow amber, or *carab.* as the French call it, is a hard, brittle, unctuous substance.

Its specific gravity is from one to two.

Its fracture is even, smooth, and glossy, capable of a fine polish: and

Becomes electric by friction.

When rubbed or heated, it emits a peculiar agreeable smell, particularly when it melts, for which effect it requires a heat of 342 degrees of Fahrenheit's thermometer. But it then loses its transparency.

Exposed on burning coals, it burns with a violet flame and a violet yellow smoke: it gives very little heat, and leaves brownish ashes.

It is insoluble in water or spirit of wine: though this latter, when distilled, extracts from it a resinous matter.

It is volatile in the retort and, when then rectified, it yields a purple colour, and may be precipitated in water. No other acid dissolves it.

But it is soluble in fixed alkalis, with a solution of acetous acid without any decomposition, and a very digestion.

See further observations below.

SECT. 234. INFLAMMABLE SUBSTANCES: 461

It is supposed to be of vegetable origin, since it is said to be found together with wood in the earth.

By distillation it yields water, oil, and a volatile acid salt, which the above-mentioned author has thought to be the acid of common salt, united with a small portion of phlogiston.

Insects,

75 gr. of this substance neutralize 100 gr. of nitrous acid; and of course, 100 gr. of yellow amber contain nearly 90 of phlogiston.

By distillation it affords a small quantity of water, an oil of the nature of petrol, and the peculiar acid called the *fuccineous*, already mentioned in Sect. 166.

100 grains of amber afford about 72 of petroleum; 4.5 of salt, *viz.* of the fuccineous acid; the remainder is a fixed matter, and water.

According to Scheele, this amber yields, by distillation, an aqueous acid, which possesses all the qualities of vinegar. If so, it is probably of a vegetable origin. *Kirwan*.

My late friend, Dr. Fothergill, was so persuaded of the truth of this last mentioned opinion concerning the origin of this substance, that he often proposed to the curious, the attempt of hardening various resins by a long deposition, or long standing, surrounded by acids, in the ground, or in proper vessels. A paper of the Doctor's may be seen in the *Philosophical Transactions* for 1743, N^o 472. on this subject.

This kind of amber, says Mr. Fourcroy, is found in small detached pieces, for the most part under coloured sands, dispersed in beds of pyritaceous earth; and above it is found wood, charged with a blackish bituminous matter. Hence it is strongly supposed, that it is a resinous substance, which has been altered by the vitriolic acid of the pyrites, notwithstanding that we know that acids, when concentrated always blacken, and charry resinous substances. In fact, the chemical analysis of this substance rather confirms that supposition.

The singular opinion of Dr. Girtanner, about the *yellow amber* being produced by a kind of ants, may be seen in *Journal de Physique*, for March 1786, page 227.

The

Insects, fish, and vegetables, are often found included in it, which testify its having once been liquid.

It is more transparent than most of the other bitumens; and is doubtless the substance which first gave rise to *electrical experiments* (on account of the power it possesses of attracting little

The colour, texture, transparency, and opacity of this substance, have shewn some other varieties, besides those mentioned in the text, the principal ones are the following;

- | | |
|--|----------------|
| 6. The yellow opaque <i>succinum</i> | } opaque |
| 7. The coloured <i>green or blue</i> , by foreign matter | |
| 8. The veined <i>succinum</i> | |
| 9. The white | } transparent. |
| 10. The pale-yellow | |
| 11. The cittron-yellow | |
| 12. The deep-red | |

The golden-yellow transparent amber, mentioned by the Author, is what the Antients called *Cbrysolætrum*: and the *white opaque* was called *Leucolectrum*.

But we must be cautious about the value of the specimens, remarkable for their colour, size, transparency, and the well-preserved insects they contain internally; since there is a probability of deception, several persons possessing the art of rendering it *transparent, coloured*, and of *softning* it, so as to introduce foreign substances, &c. into it at pleasure.

Mr. Fourcroy says, that two pieces of this substance may be united, by applying them to one another, after being wet with *oil of tartar*, and *beated*: and Wallerius mentions, that pieces of yellow amber may be softened, formed into one, and even dissolved by means of oil of *turnep-seed*, in a gentle heat; and that, according to some authors, it may be rendered pure and transparent, by boiling it in *rape-seed-oil, linseed oil, salt water*, &c.

Mr. Macquer says, that for the purpose of making varnish, this substance must undergo beforehand a previous decomposition

tle bits of straw, or of other light substances, when rubbed).

It's varieties are reckoned from its colour and transparency. It is found

A. Opaque. *Succinum opacum.*

a. Brown.

b. White.

c. Blackish

tion by torrefaction, in order to be dissolved by *linseed-oil*, or *essential-oils*.

According to Jaubert (in his *Dictionaire des Arts*), two ounces of *aloes*, and as many of *carabé*, being well dissolved with 12 ounces of linseed-oil, in a glazed earthen pot, untill the whole be uniformly incorporated, makes an excellent varnish like that of China and Japan. Great care, says he, must be taken to avoid its catching fire in the process. But I believe the mixture of *aloes* to be a mistake; as, upon enquiry, I find no where else any mention of *aloes* among the receipts or formulas for making varnishes. Unhappily this kind of books is never published by good, practical, and honest artists, because they in general make a secret of their crafts; and of course we cannot put any reliance either on scribbling theorists, or on catch-penny publishers, who hardly know the names of the things they describe.

Besides, the making varnishes with yellow-amber, this substance was much employed formerly in making various pieces of ornament and jewellery: the best pieces were cut, turned, carved, or plained, to make vases, heads of canes, colars, bracelets, snuff-boxes, beads, and other ornaments, small fine chests, &c. But after diamonds, precious and beautiful hard stones were brought to use, these trinkets are little considered in Europe: nevertheless, they are still sent to Persia, China, and to various other Eastern nations, who esteem them still as great rarities.

Mr. Fourcroy quotes Wallerius, saying, that the transparent lumps of this substance may be employed for making *microscopes*, *burning-glasses*, *prisms*, &c. But this author mentions no such thing in his edition of 1778: nor could it be preferred

c. Blackish.

B. Transparent. *Succinum diaphanum*.

a. Colourless.

b. Yellow.

The greatest quantity of European amber is found in Prussia; but it is, besides, collected on the sea-coast of the Province of Skoné; and at Biorko; in the Lake Malaren, in the Province of Upland; as also in France and in Siberia. It is chiefly employed in medicine, and for making varnishes.

preferred to glass on any account, except for trying the different refrangibility, and modifications of light. He adds also, a report of the King of Prussia possessing a burning-lens a foot diameter, of this fossil substance; and that in the cabinet of the Duke of Florence, a column of amber was seen, six feet high, and a very beautiful lustre: these both I have no objection to believe, they being rather an object of ostentation and luxury, than of any real usefulness.

The Copal is a substance very similar to yellow amber, although not so hard, and of course it takes a less beautiful polish. Some Mineralogists, among whom is Lehman, reckon it among fossils; but Boch, quoted by Kirwan, has shewn it belongs to the vegetable kingdom.

Its chemical products are for the most part the same as those of the yellow amber; but it does not produce any acid salt.

It is commonly called Gum-Copal, which is a very improper denomination, as it is a true resin. Mr. de Bomare describes the tree which produces this resin. It grows in New Spain; and Linnæus speaks of one called by him *Rhus copalinum*, &c. but it is also found on the sea coast, as well as the yellow amber. Some confound the one of these two substances with the other; but it is evident that they are very different. It is generally employed in making varnishes by dissolution in oils, or in camphorated spirits of wine, &c. *The Editor*.

SECT.

S E C T. 235. (147.)

Rock-oil. Naphtha [a].

This is an inflammable mineral substance, or a thin bitumen, of a light brown colour; which cannot be decomposed; but is often rendered impure by heterogeneous admixtures. By length of time it hardens in the open air, and then resembles a vegetable resin; in this state it is of a black colour, whether pure or mixed with other bodies. It is found,

A. Liquid.

1. *Naphtha [b].*

This is said to be of a very fragrant smell [c], transparent; extremely inflammable, and attracts

[a] Phlogiston occurs also in the fossil kingdom, combined in an oily form, but many suppose this derived from the vegetable kingdom. *Berg. Sciagr.*

Three varieties of Naphtha are known, the *white*, the *reddish*, and the *green*, or deep coloured. It is in fact a true petrol, of which the lightest, the most transparent, and most inflammable, is distinguished by this name of *Naphtha*. *Mongez.*

[b] It is a fine thin coloured oil. It swims on all fluids; and is very volatile. Is not decomposed by distillation; and yet, if long exposed to the air, it changes colour, thickens; and degenerates into petrol. Its specific gravity is = 0,708. *Kirwan* and *Mongez.*

[c] Its smell is agreeable enough; but is very different from that of vegetable oils. It dissolves resins and balsams, but not *gum-resins*, nor *elastic-gum*. It dissolves in the essential oils of thyme and lavender; but is insoluble in spirit of wine and æther. *Kirwan.*

H h

gold

466 INFLAMMABLE SUBSTANCES. Sect. 235.

gold [*d*]. It is collected on the surface of the water in some wells in Persia [*e*].

[*d*] It burns with a bluish yellow flame, and is as inflammable as æther; and, like it, attracts gold from *aqua regia*. *Kirwan*.

[*e*] It issues out of white, yellow, or black clays, in *Persia* and *Media*. *Kirwan*.

The finest naphtha is brought from a peninsula in the Caspian Sea, called *Okefra* by *Kempfer*. It issues out through the earth, into cisterns and wells, purposely excavated for gathering it at *Baku* in Persia.

Different Naphthas are found also in Italy, in the Dutchy of Modena, and in Mount *Ciaro*, twelve leagues from Plaisance.

Most naturalists and chemists ascribe the formation of *Naphtha*, *Petrol*, &c. to the decomposition of solid bitumens by the action of subterraneous fires; so that *Naphtha* is the lightest oil which fire disengages first: what follows, acquiring colour and consistence, forms the different sorts of *petrol*; and these last, united with some earthy substances, or altered by acids, assume the appearance of *mineral pitch*, *pissasphaltum*, &c. The phenomena, which the distillation of yellow-amber presents, seem to support this opinion, as it really furnishes a kind of *naphtha*: then a *petroleum*, more or less brown: and finally, a black substance, like the *jet*, which, urged by the fire, leaves a brittle and porous matter, &c. They observe further, that Nature presents frequently all kinds of petrol near the same spot, from the lightest naphtha to the mineral pitch, as may be observed at Mount *Feslin*, in the Dutchy of Modena. But although this opinion be the most plausible, some think that these mineral oils, or bitumens, are formed from the vitriolic acid, and various oily and fat substances of the *vegetable* and *animal* kingdoms, buried under the earth by the ancient convulsions and revolutions of this globe, previous to all historical records of mankind. *The Editor* from *Wallerius*, *Mongez*, *Kirwan*, *Fourcroy*, &c.

S E C T.

S E C T. 236. (148.)

2. Petrol. *Petroleum*, Lat. *Bergoel*, *Steinoel*, Germ.

This smells like the oil of amber, though more agreeable; and likewise very readily takes fire. It is collected, in the same manner as the Naphtha, from some wells in Italy, and in a deserted mine at Osmundsberget, in the province of Dalarna. At this last-mentioned place, it is found in small hollows in the lime-stone, as resin is in the wood of the pine-tree [a].

S E C T.

[a] Doctor Priestley has shewn, in the third volume of his *Observations and Experiments on Air*, that essential oils, long exposed to the atmosphere, absorb not only the pure part, but also the phlogisticated part of it: an absorption, which must in time produce considerable changes in them. By a process of this sort, naphtha is converted into petrol, which is an oil of various degrees of density, according to the time during which it has been exposed to the atmosphere. Petrol is found trickling from rocks, or issuing from the earth, in the Dutchy of Modena, and in various parts of France, Switzerland, Germany, and Scotland, as well as in Asia; also on the surface of the water of different fountains, or mixed with earth and sand, from which it is separated by infusion in water. The thinnest sort possesses the properties of naphtha, though in a less degree. It is rendered finer by distillation with water, and leaves a resinous residuum; and if distilled with a volatile alkali, the alkali acquires the properties of succinated ammoniac, and contains the acid of amber. Some sorts of it, according to Monet, are nearly of the density of nut-oil. It is insoluble in spirit of wine. *Kirwan*.

H h 2

The

S E C T. 237. (149.)

Maltha. Barbadoes-tar.

Petroleum tenax. Kedria-terrestris, Lat.
Erdepeck, Bergtheer, Germ.

B. Thick and pitchy rock-oil.

This resembles soft pitch [a]

It

The distinct character of the petrol, is its thickness, resembling inspissated oil: its smell approaches that of turpentine, or rather oil of amber: its flavour is of a penetrating sharpness; and, when pure, it is lighter than spirit of wine. In process of time it loses its smell and former colour, becoming black and thick.

There are three varieties of Petrol, *viz.*

The yellow, very light and volatile. It is found near Modena in Italy.

The reddish, or yellow-red; some of which is collected near Gabian in Languedoc, and in Alsatia.

And the black, or brown, which is heavier and more common. This is found in England, France, Italy, Germany, Sweden, and in various other places. It generally either runs out from the chinks, or gaps of rocks; or is mixed with the earth, and gushing out of it; or swimming on the water of some fountains, &c. *Mongez.*

Dr. Lippert says, that on mixing fuming *nitrous* acid with petrol, a kind of rosin is produced, whose taste is very bitter, but the smell is like that of *musk*; and that the *vitriolic acid* produces with it a still more bitter substance, but without that aromatic smell. *Editor.*

[a] Petroleum, long exposed to the air, forms this substance. It is of a viscid consistency; and of a brown, black, or reddish black colour. Sometimes inodorous, but generally of

SECT. 238. INFLAMMABLE SUBSTANCES. 469

It is found in Mossgrufvan, at Norberg, in the province of Westmanland, and at the Dead Sea in the Holy Land [b].

S E C T. 238. (Additional.)

Elastic Petrol.

This is a very singular fossil found of late in England.

By its colour and consistency it exactly resembles the *Indian-rubber*, or the *gum-resin* from the North part of Brasil, called *Caoutchouc*, commonly used for rubbing the traces of *black-lead pencils* from paper, as was mentioned in the Note to page 454.

It is of a dark brown colour, almost black; and some is found of a yellowish brown-cast, like the same gum-resin.

of a more or less disagreeable smell, particularly when burned. It easily melts, and burns with much smoke and soot; and leaves either ashes or a slag, proceeding from the heterogeneous matter it contains.

It is insoluble in spirit of wine.

Contains a portion of the succinous acid; since it gives, with mineral alkali, a bitter salt, more difficultly dissoluble than common salt, and which, being treated with charcoal, will not afford sulphur. *Kirwan*.

[b] It is found in Persia, in the chinks of rocks, and in strata of gypsum and lime-stone; or floating on water; also in *Siberia*, *Germany*, *Switzerland*, in coal-pits: and in *America*. *Kirwan*.

And also in Colebrookdale in England. *Brun*.

H h 3

With

With respect to its elastic consistence, it hardly can be distinguished from it, except in the cohesion of its particles, which is weaker.

It has the same property of rubbing off from paper the traces of black-lead pencils.

It burns likewise with a smoky flame; and also melts into a thick oily fluid; but emits a disagreeable smell, like the *fossil pitch*, or *Barbadoes-tar* of the last Section.

It is found in the same earthy and stony beds as petrol; namely, among spar and lead-ores; and some lumps of this hard substance (*viz.* the *Asphaltum* of the following Section) are found in the same spot along with it.

Some specimens of this fossil are of a cylindrical form, like bits of thin branches or stalks of vegetables, though much more flexible, being perfectly elastic.

Upon the whole, this fossil seems to confirm the opinion already mentioned, Note to page 466, of those Mineralogists, who believe that these oily combustibles derive their origin from the vegetable kingdom. It seems worth trying, whether pieces of *Asphaltum*, buried in damp beds of sparry rubbish, or other kind of earths, would take the same elastic consistence.

But since many beds of *shells* and other *fossil substances*, both of the *vegetable* and *animal kind*, as impressions of various *plants*, and the remains of various *quadrupedes*, &c. have been found in different parts of the globe, whose individual species undoubtedly exist no longer alive unless

Sect. 239. INFLAMMABLE SUBSTANCES. 471

unless in far distant climates, and in the most remote countries from the spot where their exuvia are digged out ; why should we not allow that this new fossil may be the same original *elastic gum*, now growing naturally in *Brazil, China*, and other *hot climates*, only altered in its smell, and in the tenacity of its particles, by the long standing during centuries, and even myriades of years, buried in the bowels of the earth ?

This elastic petrol was found in 1785, near *Cassleton*, in the County of *Derbyshire*, in *England*, but in very inconsiderable quantities, of which I got some very small pieces. *The Editor.*

S E C T. 239. (150.)

C. Hardened Rock-oil. Fossil Pitch. *Petroleum induratum. Pix montana.* Lat. *Iudenpech, Bergbartz, Steinpech, Erhartete, Bergtheer.* Germ.

1. Pure, *Asphaltum.*

This leaves no ashes or earthy substance when it is burnt [a].

[a] This is a smooth, hard, brittle, inodorous, black or brown substance. When looked through, in small pieces, appears of a deep red colour. It swims in water.

It breaks with a smooth shining surface. Melts easily : and, when pure, burns without leaving any ashes ; but if impure, leaves ashes or a slag.

According to Mr. Monet, it contains sulphur, or at least the vitriolic acid.

It is slightly and partially acted on by alcohol and æt. cr.

Kirwan and M. g. z.

H h 4

It

It is found at Finnberget, in the parish of Grythyttå, in Westmanland [b].

From this or the preceding substance, it is probable, the asphaltum was prepared that the Egyptians used in embalming their dead bodies, and which is now called *Mummia*.

2. Impure, *Pix montana impura*,

This contains a great quantity of earthy matter, which is left in the retort after distillation, or upon the piece of charcoal, if burnt in an open fire; it coheres like a slag, and is of the colour of black-lead: but in a calcining heat this earth quickly volatilises, so that the nature of it is not yet known [c].

It is found in Mossgrufvan in Norberg, and in Grengierberget, both in the province of Westmanland: and also in other places [d].

[b] It is found also on the shores of the *Red Sea*, in the *Dead Sea*, in *Germany*, and *France*. Kirwan.

And it comes likewise from *Porto Principe*, in the island of Cuba. Brun.

Is found also in many parts of China: and is employed as a covering to ships by the Arabs and Indians. Fourcroy.

[c] The substance which rises, and then falls into the receiver during the distillation of this fossil pitch, is entirely the same as the common natural liquid rock oil of Sect. 148.

The Author.

[d] The *Pissasphaltum* is of a mean consistence, between the *Asphaltum* and the common Petroleum.

It is the very bitumen which is collected in Auvergne in France, in the well called *de la Pege*, near *Clermont-Ferrand*.

Mongez.

S E C T.

SECT. 240. (Additional.)

Jet. *Gagas*, *Succinum nigrum*. Lat. *Jet*,
or *Jayet*. French.

The *jet*, the *lapis obsidianus*, and the *fossil wood*, penetrated by mineral inflammable matter, are often confounded together by Naturalists, on account of their black glossy colour, and some other common properties. But the *lapis obsidianus*, or *galinaceus*, is properly a glassy substance produced by volcanic fires, which must be placed in the Appendix among the volcanic productions, as well as the *fossil-wood* described by our Author in his Sect. 285.

As to the jet, it is a very compact bitumen, harder than asphaltum, always black, and susceptible of a good polish. It becomes electrical when rubbed, and attracts light bodies like the yellow amber. It swims on water, and of course its specific gravity must be less than 1000, whilst that of the *lapis obsidianus*, according to Kirwan, is no less than 1744.

It seems to be nothing else than a *black amber*, or *succinum*, but specifically lighter, on account of the greater portion of bitumen that enters into its composition. When burned it emits a bituminous smell.

It is never found in strata, or in continued masses, like the quarries of fossil stones, but in
separate

474. INFLAMMABLE SUBSTANCES. Sect. 240.

separate and unconnected heaps, or in single pieces like the true yellow amber, described in Sect. 234. See Bomare's Mineralogy, tom. 2. p. 435. Edition of 1774.

Great quantities of this fossil have been dug up in the *Pyrenean* mountains; also near *Batalha*, a small town in Portugal, where it is called *Azebiche*: and in *Galiza*, a Northern Province of Spain. It is found also in Ireland, Sweden, Prussia, Germany, and Italy, &c. [a].

This fossil is used in making small boxes, buttons, bracelets, and mourning jewels or trinkets. Sometimes it is employed for making black varnishes with proper oils; and is said, that when powdered, it makes with lime an extraordinary cement, both for hardness, duration, and solidity, &c.

Editor, from Kirwan, Bomare, Lippert, Mongez, &c.

[a] Jet so much resembles Cannel-coal in its colour, in its hardness, in its receiving polish, in its not soiling the fingers when rubbed upon it, &c. that many authors confound the two substances together. Jet, however, when warmed by friction, has the property of attracting bits of straw and other light bodies; but I never observed this property in any of the cannel-coals. *Watson's Essays*, vol. III. p. 11

This respectable Author might add also the other characteristic of jet being lighter than water, as Wallerius, Bomare, Mongez, and others assert. If so, he must have been misinformed by those, who say that the cubic foot of jet weighs 1238, or at least 1180 ounces, and that of cannel-coal 1273 ounces, on the supposition that the cubic foot of water weighs only 1000 ounces. *The Editor*.

S E C T. 241. (157.)

Mineral Phlogiston united with earths.

Phlogiston minerale terris imbutum.

A. with calcareous earth. Phlogiston terra calcarea imbutum.

1. With *pure calcareous earth*. This is the *fetid*, or *swine spar* of Sect. 29.

S E C T. 242. (157.)

Liver-stone. *Lapis hepaticus.*

B. Mineral phlogiston united with calcareous (argillaceous, ponderous, and siliceous) earth, and vitriolic acid [a].

[a] This is the *liver stein* of the Swedes, and the *leber stein* of the Germans, already described in Sect. 52. The Noble author said, in that place, that no calcareous earth could be found in this stone, although, when burned, it produced a very good lime. This certainly was a contradiction, arising from the want of a good analysis never having been made before of this substance: but Bergman, in his *Sciagraphia*, Sect. 90. affirms, that 100 parts of this stone, contain 33 of *siliceous* earth; 29 of caustic *ponderous* earth; almost 5 of *argillaceous* earth, and 3.7 of *lime*, besides the *vitriolic* acid, and the water of crystallization. Mr. Kirwan, however, quotes another analysis of the same Professor Bergman, by which it appears, that 100 parts of the *hepatic stone* contain 33 of *baroselenite*, 38 of *siliceous* earth, 22 of *alum*, 7 of *gypsum*, and 5 of mineral oil. *Editor.*

S E C T.

S E C T. 243. (158.)

Pitt, or stone-coal. *Lithanthrax*,

C. With an argillaceous earth, *Phlogiston argilla mixtum*.

1. With a small quantity of argillaceous earth, and vitriolic acid. Coal. *Lithanthrax* [a].

It is of a black colour, and of a shining texture; it burns, and is mostly consumed in the fire; but leaves however a small quantity of ashes.

a. Solid coal.

b. Slatty coal [b].

Found in England, and at Boserup in the province of Skone,

S E C T.

[a] It is a black, solid, compact, brittle, inflammable substance; of a moderate hardness, lamellated texture, more or less shining, but rarely susceptible of a good polish; and does not melt when heated.

According to Kirwan, it consists of petrol, or asphaltum, intimately mixed with a small proportion of earth, mostly argillaceous; seldom calcareous, and often with pyrites.

Spirit of wine extracts a red colour from it: caustic alkali attacks the bituminous part; and fat oils act on it, and form varnish, at least with some sorts of it. Fixed alkali has never been found in it, nor any sulphur, except when it contains pyrites.

None of the various kinds of pit-coal are electrics *per se*.

Kirwan.

[b] The varieties of pit-coal are very numerous, according to the proportion of each integrant part of their substance; but

S E C T. 244. (159.)

2. Culm-coal, called *Kolm* by the Swedes.

This coal has a greater quantity of argillaceous earth and vitriolic acid, and a moderate proportion of petrol.

It

in regard to their economical uses, only two varieties are attended to by the Legislature of England, establishing a difference in the duty payable by *culm*, and *caking coals*; the last consist of those coals, that, in burning, shew a beginning to melt, so far that their smallest pieces run together, and unite by the adhesion of their surfaces: on account of this property it seems immaterial of what size the pieces are, since the smallest parts coalesce by fusion into consolidated matter; and consequently, the refuse or dross of these coals furnish a fuel fit for the common economical purposes of life.

The other sort of pit-coals, which are indicated by the name of *Culm*, or *Kolm*, in the following Section, do not fuse, unite, nor cake by the application of heat, but retain their original form, and keep in detached pieces in the midst of fire. The small of this coal cannot therefore be applied to domestic use; because, when in powder, this coal-dust insinuates itself between the crevices, prevents the circulation of air, and chokes up the fire, extinguishing it as completely as a parcel of imcombustible matter. It is the fragments and dust of this coal which constitutes *culm*, and which is only applicable to burn *lime-stone* for reducing it to *lime*, and to bake bricks, which are two very valuable articles of public concern.

It should be an easy matter for any person to distinguish *culm* from small *caking coal*, either by trying to make fire with it in a common grate, without interposing other fuel between it; for if it does, it is a *caking coal*; if not, it is *culm*; otherwise, by putting some of these small fragments of coal on an ignited iron shovel; if they melt and run together, they belong

It has the same appearance with the preceding one, though of a more dull texture; it burns with a flame, and yet is not consumed, but leaves behind a slag of the same bulk or volume as the coal was.

From England, and among the alum rock at Moltorp and Billingen in the province of Westergottland [a].

S E C T.

belong to the *taking kind*: if not, they are *culm*. But it seems that coal-merchants are now in the custom of calling *culm* the powdery parts of pit-coal, of whatever sort or kind they may happen to be.

There never was any difficulty on the subject; and there would be no trouble in collecting the tax, were it not for the insufferable ignorance and love of despotic oppression, which generally pervades the underling officers of the revenue.

Editor, chiefly from Russel's Notes.

[a] Mr. Kirwan has given a description of this kind of coal, extracted from The Memoirs of the Stockholm Academy. Its fracture has a rougher surface, than the *cannel-coal* of the following Section 246

Its specific gravity is from 1300 to 1370.

The best coal of this sort affords, by distillation, at first *fixed air*, then an *acid liquor*, afterwards *inflammable air*, and a *light oil* of the nature of petrol, then a *volatil alkali*; and, lastly, *pitch-oil*. The residuum is nearly three quarters of the whole; and being slowly burnt, affords 13 *per cent.* of *ashes*, which consist mostly of argillaceous earth: and about three hundred parts of them are magnetic.

However, according to the analysis of Mr. Kirwan, 100 parts of this coal contain about 17 of earth, of which 4 are martial; and from hence it appears, that this coal does not consist of a shistus penetrated with petrol, as some have thought, for then a large portion of siliceous, magnesian, and calcareous earths, should be found in it.

S E C T. 245. (160.)

3. Slate-coal [a].

This coal contains abundance of argillaceous earth. It burns with a flame by itself, otherwise it looks like other slates.

It is found at Gulleråsen, in the parish of Rettwik, in the province of Dalarne, and also with the coals at Boferup in Skone.

S E C T.

It will be necessary to notice here, that coal-merchants in general hardly make any difference in the specific quality of pit-coals, provided they find buyers to dispose of them, and that the duties or taxes be the least possible to pay; so that what is called by them *Culm*-coal, means only the powdery rubbish, or dross of any sort of coals for making lime, or baking bricks, &c. See Note [b] to the preceding Sect. 243.

The Editor.

[a] This last mentioned kind has induced me to believe, that the earth of the pit-coals is an argillaceous one, but is not so easy to be discovered after its being burnt. The pit-coals contain more or less of the vitriolic acid, for which reason the smook, arising from them, attacks silver in the same manner as sulphur does; though the coals be ever so free from marcasite, which however is often found imbedded or mixed with them. *The Author.*

This is undoubtedly the *bituminous schistus*, already described in Sect. 148 among the *argillaceous earths*. I have seen, since that Section was printed, a considerable quantity of this stony substance, which was sent from *New Hall*, near *Thirsk* in *Yorkshire*, to Mr. Walker, Lecturer of Natural Philosophy in London.

This

S E C T. 246. (Additional.)

4. *Cannel-coal.*

Mr. Kirwan has put together this variety of coal, with that other called *Killkenney-coal*, though they have some different properties.

The *cannel-coal* is of a dull black colour.

Breaks easily in any direction; and, in its fracture, presents a smooth conchoidal surface, if broken transversely.

Contains a considerable quantity of petrol, in a less denser state than other coals.

Burns with a bright lively flame, but is very apt to fly in pieces in the fire. It is said, however, to be entirely deprived of this property by being previously immersed in water for some hours.

Its specific gravity is about 1270.

And being of an uniform hard texture, may be easily turned in the lathe, and receive a good polish.

This *schistus* is of a dark bluish rusty colour: when thrown in the fire, burns with a lively flame, and as readily almost as the oily wood of dry *olive-tree*, or *lignum vitæ*; and emits the very disagreeable smell of petrol. Mr. Walker extracted from it, by distillation, as much *liquid petrol*, as nearly its own bulk. I am well informed, that near *Purbeck*, in Dorsetshire, such large quarries of this slate are found, as to afford competent fuel to the poorer part of the inhabitants of that place.

The Editor.

L

SECT. 248. INFLAMMABLE SUBSTANCES. 481

It is from this kind of coal that small vases, as ink-stands, various trinkets, and other curiosities, are made in England, which appear as if made of the finest Jet.

Editor, chiefly from Kirwan.

S E C T. 247. (Additional.)

Kilkenny-Coal.

This coal contains the largest proportion of *Petrol* or *Asphaltum*; burns with less flame and smoke, and more slowly, though intensely, than the *cannel-coal*.

The quantity of earth in this coal, does not exceed one *twentieth* of its weight.

Its specific gravity is about 1400.

It is frequently mixed with pyrites.

Is found in the County of Kilkenny, belonging to the province of Leinster, in Ireland. The quality of this coal burning almost without smoke, is mentioned in a proverb, by which the good qualities of this County are expressed. *The Editor, chiefly from Kirwan.*

S E C T. 248. (Additional.)

Sulphureous coal.

This consists of the former kinds of coal, mixed with a notable proportion of pyrites:

I i

hence

482 INFLAMMABLE SUBSTANCES. Sect. 249.

hence it is apt to moulder and break when exposed to the air.

It contains yellow spots that look like metal:

And burns with a sulphureous smell, leaving either red ashes, or a slag, or both.

Water acts upon it, after it has mouldered.

Its specific gravity is = 1500, or more.

Besides the above varieties, shistus, micaceous shistus, and gneiss, are frequently found in the neighbourhood of coal-mines, so penetrated with petrol, or bitumen, as to constitute an inferior species of coal; but the bitumen being burnt, they preserve their form, and in some measure their hardness.

Also some grey flates, that are so soft as to be scraped with the nail, and are greasy to the touch, burn like coal.

All the differences of coal arise from a mixture of the varieties already mentioned; and

It is observable, that wherever coals exist, flates are generally found near them. Salt, or mineral springs, are also often found in their neighbourhood. *Kirwan.*

S E C T. 249. (Additional.)

Bovey Coal. Taub Kohle. Xylanthrax.

This is of a brown, or brownish black colour, and of a yellow laminar texture.

The

Sect. 250. INFLAMMABLE SUBSTANCES. 483

The laminae are frequently flexible when first dug, though generally they harden when exposed to the air.

It consists of wood penetrated with petrol or bitumen, and frequently contains *pyrites*, *alum*, and *vitriol*.

Its ashes afford a small quantity of *fixed alkali*, according to the German chemists; but, according to Mr. Mills, they contain none.

By distillation it yields an ill smelling liquor, mixed with a *volatile alkali* and *oil*; part of which is soluble in spirit of wine, and part insoluble, being of a mineral nature.

It is found in England, France, Italy, Switzerland, Germany, Ireland, &c. *Kirwan*.

S E C T. 250. (Additional.)

Peat. *Geanthrax*.

There are two sorts of inflammable substances known by this name; *viz.*

The first of a brown, yellowish brown, or black colour, found in moorish grounds; in *Scotland*, *Holland*, and *Germany*. When fresh, it is of a viscid consistence, but hardens by exposure to the air.

It consists of clay mixed with calcareous earth and pyrites: and sometimes contains common salt.

While soft it is formed into oblong pieces for fuel, after the pyritaceous and stony matters are separated.

When distilled it affords *water, acid, oil, and volatile alkali.*

Its ashes contain a small proportion of fixed alkali. They are either white or red, according as it contains more or less ochre or pyrites.

The second is found near Newbury in Berkshire. It contains but little earth; but consists chiefly of wood branches, twigs, roots of trees, with leaves, grass, straw, and weeds.

Kirwan.

S E C T. 251. (Additional.)

Stone-Turf.

The Noble Author has ranged the turf among the fossils of his Appendix; but as that called in England by the name of *stone-turf*, contains a considerable proportion of peat, it may be mentioned with propriety in this class.

Soon after it is dug out from the ground, where it keeps a soft consistence, it at first hardens; but afterwards it crumbles by long exposure to the air.

As to the other common turf, it only consists of mould interwoven with the roots of vegetables; but when these roots are of the bulbous kind, or in a large proportion, they form the worst kind of turf.

Although it may appear incredible, it is nevertheless a real fact, that in England pit-turf is advantageously employed in *Lancashire*, to

Sect. 252. INFLAMMABLE SUBSTANCES. 485

smelt the iron-ore of that county. Mr. Wilkin- son, brother-in-law to the celebrated Dr. Priestley, and himself not less famous for his extensive undertakings in the iron-works, per- haps the greatest in all Europe, makes use of pit-turf in his large smelting furnaces of that province. I have seen, in the possession of Mr. S. More, Secretary to the Society of Arts, a kind of *black tallow*, extracted by the same Mr. Wilkin- son, from *pit-turf*. It was very soft, and nearly of the same consistence as butter. It burned very rapidly with a smoaky flame in the fire; but the smell was very disagreeable like that of pit-turf. This confirms the opinion that the tallow described in Section 232, is probably of a fossil extraction, as well as the other oils mentioned in the preceding Sections; although the origin of them all may be from the *vegetable* and *animal* kingdoms. *The Editor.*

S E C T. 252. (Additional.)

Observations on Fossil-Coals.

These fossil substances, which furnish fuel for the various purposes of human life, are distinguished by the name of *Coals*, on account of their being a succedaneum for wood and other vegetable productions, which, when dry, or of an oleaginous kind, serve for the same uses. If these vegetable substances are deprived of the

access of air, by covering them after ignition, the half consumed remainder, which is of a black colour, is called by the name of *Coal*, or *Char-coal*; and from hence the fossil, which affords fuel, has also been called by the same name, though of a very different nature.

Pit-coal and *earth-coal* are synonymous, and mean coals dug out of a *pit*, or from the *earth*. But the *lithantrax* denotes *stone-coal*, and more properly indicates the *Cannel-coal* of Sect. 246; which has the greatest similarity to a *stony substance*, by the dull appearance of its fracture, and by the uniform texture of its parts.

All these coals are in general a bituminous black, or brown, and dark substance [*a*]: for the

[*a*] It is known that pit coal, or sea coal, by distillation, gives out a phlegm, or watery substance; then an æthereal or volatile oil; afterwards a volatile alkali; and lastly, a thick and greasy oil. But it is remarkable that by rectifying this last oil, a transparent, thin, and light oil, of a straw colour, is produced, which, being exposed to the air, becomes black, like *animal oils*. *Fabroni*.

From this, and other observations, the most general opinion is, that all coals, bitumens, and oily substances, found in the mineral kingdom, owe their origin to the animal and vegetable remains buried in the bowels of the earth; since it is well known, that only organised bodies have the power of producing oily and fat substances. The amazing irregularities, gaps, and breaks of the strata of coals, and of other fossil substances, evince that this globe has undergone the most violent convulsions, by which its parts have been broken, detached, and overturned in different ways, burying large tracts of their upper surfaces, with all the animal and vegetable productions there existing, at the time of those horrible catastrophes, whose epoch as far precede all human records. And it is easily
to

the most part they have a lamellated texture, which breaks easily, and almost always with a shining surface.

The varieties of pit-coals, already mentioned in the foregoing Sections, are the most remarkable, by which they may be distinguished from one another [b]. But they are far from being homogeneous in each kind; as the accidental

to be conceived, that the various heaps and congeries of these vegetable and animal substances, remaining for ages and ages in different parts of the bowels of the earth, have obtained various consistences, and still produce those oily and bituminous juices, which find way to gush out, leaving behind their thickest parts on the same places where they are found, and in many others where the industry of mankind never will be able to penetrate. It will be seen by the last Sect. 259. of this Class, that our author inclines very much to this opinion.

See the feeble arguments of Mr. le Camus to prove the contrary, at page 178. of Journ. de Phys. for March, 1779. The Editor.

[b] Mr. Bertrand, in his Oryctologic Dictionary, reduces all kinds of coals to six general classes, viz. 1. *Lithantrax Ligneus*. 2. *Petrassus*: 3. *Terristris*: 4. *Piceus*: 5. *Fissilis*: 6. *Mineralisatus*. He says, that the *Scotch coals* are heavier, and burn not so well as those of Newcastle; that those of Liege burn quicker, and those from *Brassac*, in Auvergne, and from *la Fosse*, burn with a more agreeable flame, &c. But Mr. Morand, in his *Nomenclature raisonnée*, distributes all sorts of *Pit coals* into 4 classes: in the first he places 9 varieties, beginning with the *gagas*, or *succinum nigrum*, to the *variegated lithantrax*: in the second, he reckons 7 varieties, beginning with the *Lithantrax eleganti structura*, to that *succie granulata*: and he forms the fourth class with the earthy and poorer kind of fossil coals. He seems, however, to have been puzzled with the slaty coals, as he ranges them in a separate class, perhaps, to shelter himself from the critical objections of those numerous superficial naturalists, who only look for the apparent configuration, without almost any regard to the component parts of fossils. The Editor.

qualities, and the various proportions of their component parts, produce a far greater number of properties, which renders them more or less fit for different purposes; though these are generally overlooked, and confounded with the common one of affording fuel for making fire, to warm our rooms, or for culinary operations.

In fact, various kinds of different coals are often found intermixed with one another in the ground. Some of the finer sort run many times in form of veins between the layers of the coarser kind; as I observed in the fine coals, the workmen employed at Birmingham, in a curious manufactory for moulding rods, or canes of transparent and coloured glass, into the required shapes for common buttons, with an astonishing expedition. The fire burned with so clear a flame as I never saw produced by common sea-coal; and I found, upon inquiry, that this particular kind of coal, was picked out from the common coals of that country, it running in particular veins, which the manufacturers know well to be fit for their purpose, though I could not find any distinctive denomination to indicate this specific difference. There is no doubt but a great field both for the theoretic investigation of the nature and original formation of this fossil, as well as for the practical knowledge of the uses to which it may be advantageously employed, remains still unexplored, or at least is yet concealed among few interested practitioners, without affording any extensive advantage to the public.

That

That kind of coal, distinguished in London by the name of *Scotch-coals*, produce, when burned, white ashes and a less dirty dust than the common *Newcastle-coals*; though, among these last, some pieces of the Scotch kind are frequently found. On the contrary, those I have seen in the fire-places at Wiltshire, made such a quantity of brown ashes and dirty dust, as to spoil the furniture in a short time, unless proper care was taken to clean the rooms very frequently.

This fossil bitumen, as Fourcroy remarks, being heated in contact with a body in combustion, and a free access of air, kindles the more slowly, and with more difficulty, as it is more weighty and compact. When once kindled, it emits a brisk and very durable heat, and burns for a long time before it is consumed. If extinguished at a proper time, the remaining cinders may serve several times for a new firing, with a small addition of fresh coals. The matter that is burned, and produces the flame, appears very dense, as if united to another substance, which retards its destruction. Upon burning, it emits a particular strong smell, which is not at all sulphureous, when the earth-coal is pure, and contains no pyrites [c].

When

[c] Hence we see how false and deceiving are the propositions of some ignorant pretenders, who boast of processes, to deprive pit-coals of sulphur, as a great improvement to destroy the noxious qualities they suppose arising from this kind of fuel. But a general and constant experience of the numerous inhabitants of England, and of various other countries on the Continent, as at Liege, part of Holland, and the Austrian

When the combustible, oily, and most volatile parts, contained in the earth-coal, are dissipated and set on fire by the first application of heat; if the combustion is stopped, the bitumen retains only the most fixed and least inflammable part of its oil, and is reduced to a true charry state, in combination with the earthy and fixed base. Pit coals in this charry state are called *Coaks*, which are capable of exciting the most intense heat; and are employed all over England in the smelting of *iron, copper*, and other metallic ores to the greatest advantage [*d*].

SECT.

Austrian Netherlands, where pit coals are the common fuel, evinces the fallacy of their imposition; and to this I may add, the experience of above twenty-two years, during which I have lived in England, without ever finding in myself, nor in any of my numerous acquaintance, the least alteration in health on this account. *The Editor.*

[*d*] It is well known that the English method of burning *pit coal* into *coak*, has been a most profitable and happy acquisition, for the smelting our ores, and for many other metallurgical and chemical processes in this island. But the ingenious and advantageous undertaking of Lord Dundonald, by which he turns to a very considerable profit the mines of coals in his and other estates, building ovens of a proper construction to burn *pit coal* into *coak*, and, at the same time, to collect in separate receptacles the *volatile alkali, oil, tar*, and *pitch*, which were generally lost by the usual method, deserves to be noticed in this place, as it affords a very remarkable instance of the great losses to mankind, for want of carefully attending to every result from great processes of art, when made in a large scale. These ovens are so contrived as to admit an under supply of air; and the coals, after

S E C T. 253. (151.)

Brimstone. Sulphur.

The Mineral Phlogiston, or Bitumen, united with the vitriolic acid, constitutes *sulphur*, or Brimstone [a].

This

after being kindled, decompose themselves by a slow, but incomplete combustion, which does not destroy the ingredients. The residuum, left in the oven, proves to be the most excellent *cinders* or *coaks*; whilst the volatile parts, which otherwise would be dissipated in the air, are separated and condensed in reservoirs, or receptacles of a capacious size, placed at proper distances beyond the reach of fire:

Mons. Faujas de St. Fond, who visited these works in a trip he made to Scotland, undertook to erect a similar oven of the kind, on his going back to France: and it is rather singular, that he endeavours to establish a claim of having discovered the same processes before he saw them in Scotland; as if it did not reflect a greater honour on his industry, to carry back to his country some useful knowledge in consequence of his travels, than to return as ignorant as our English travellers usually do, whose acquisitions seldom amount to more than the new fashions, effeminate manners, and other silly trifles, which our degenerate Britons are now wont to call refined accomplishments. *The Editor.*

[a] This has been the general doctrine of chemists since the time of the famous Stahl, who called, by the name of *Phlogiston*, that very inflammable principle, that had been described by Beccher, under the name of *inflammable earth*. Stahl was the first who discovered the synthetic composition of sulphur, by combining a combustible substance with *vitriolic acid*; and this has afforded the greatest probability, amounting

This is very common in the earth, and discovers itself in many and various forms. It is found,

A. Native

amounting indeed almost to a demonstration, of the truth of his theory. Macquer describes this process, which consists in mixing equal parts of *fixed alkali* and *vitriolated tartar*, with about the fourth part of both of powdered charcoal, in a crucible: the mixture being well stirred with a wooden rod, and the covered crucible placed on the fire for a short time, the matter is poured out, on a greased marble: emits a strong disagreeable smell, like that of rotten eggs: when cold, coagulates, and appears of a dark-red, or liver colour: and is a true *liver of sulphur*. This being dissolved in water, affords a yellowish precipitate on the addition of any acid, which being collected on the filtre, is found to be a true brimstone.

According to this doctrine of Stahl, the *phlogiston* of the charcoal unites with the vitriolic acid of the tartar, or of any other vitriolic compound, and forms sulphur; but, according to the new pneumatic theory, at the head of which is one of the most ingenious chemists of our times, Mr. Lavoisier, the rationale of these phenomena is quite the reverse of what has been asserted by the followers of Stahl. Those bodies which were called *phlogisticated*, are nothing more, according to the new theory, than substances which have a great tendency to unite with *pure air*; a tendency, which in general constitutes *combustibility*. So that whenever Stahl affirms *phlogiston* to be disengaged, as in *combustion* and *calcination*; there is in fact nothing else, say the new theorists, but a real combination of this *pure air*, with some of the component parts of the burned substance, the process being facilitated by the action of *heat*. On the other hand, in all the supposed combinations of *phlogiston*, a disengagement of air may be often observed to subsist, as is evident in the reduction of metallic calces, and in the decomposition of bodies by the action of acids. In a word, in this pneumatic system, all these compounds of Stahl, as *sulphur* from vitriolic acid, and *metals*, from their *calces*, and *phlogiston*, are only simple substances, which possess a great tendency to unite with *dephlogisticated*

A. Native Sulphur, Sulphur nativum.

In this the two constituent parts are mixed in due proportion in regard to each other, according to the rules of that attraction which is between them ; it is easily known,

1. By its inflammability, and by its flame [b].

2. By

gified air. Thus metals unite with the same air on being calcined : and their calces, on being reduced by fire into their metallic state, give out the air they had imbibed before. I must confess that the simplicity of the *Pneumatic Theory* is a great inducement to receive it ; but until any *sulphur* can be shown, preexisting in the alkaline base of the *vitriolated tartar* (for the *vitriolic acid* runs off, according to this theory, in the form of *pure air*, to combine with the *charcoal*) no man, in an unprejudiced state of mind, will venture to embrace such a theory. Neither is it at all comprehensible, how the same agent *fire* will produce two opposite effects in similar circumstances ; viz. causing pure-air to *unite* with metallic bodies in *calcination* : and to be *separated* from them, when they are revived by the same. *The Editor.*

[b] Sulphur evaporates gently at the 170 degree of Fahrenheit's thermometer.

Melts at 185 degrees ; and

Flames at 302 degrees of the same thermometer.

Burns with a blue flame, and a disagreeable suffocating smell.

Sublimes in close vessels, without decomposition, except of a small quantity, proportioned to the quantity of air contained in the vessels.

When melted becomes red, but recovers its colour on cooling.

Its constituent parts, viz, the *vitriolic acid* and *phlogiston*, are nearly in the proportion of 3 to 2 ; for 100 parts of sulphur contain about 60 of this *acid*, and 50 of *Phlogiston*.

It

2. By its smell, when burnt; and,
3. By its producing a liver of sulphur, when mixed with a fixed alkali, like that made from artificial sulphur [c].

It

It is a tasteless, hard, brittle, idioelectric substance, of a yellow greenish colour.

Its specific gravity is from 1900 to 2350.

It is insoluble in water, though, by long trituration, the water seems to take up some part of it; but it seems that it is rather diffused thro', than dissolved in it.

Neither can spirit of wine unite to it, except when both are in a vaporous state; and then 72 parts of spirit of wine take up *one* of sulphur.

Is soluble in hot oils, and also in alkali, both in the dry and liquid way.

Is decomposed by boiling in concentrated nitrous acid; partly decomposed, and partly dissolved by the vitriolic and dephlogisticated nitrous acid. *Kirwan*.

[c] The two pure (caustic) fixed alkalis, *vegetable* and *mineral*, have a very remarkable action on this substance; as, they form true *livers of sulphur*, which are most difficultly decomposed, and the most permanent of all. They may be prepared by the *dry*, or by the *moist* way. In the first process, equal parts of *lapis causticus* and *flowers of sulphur* are fused in a crucible; then run on a marble plate; and, as soon as cooled, are broken into pieces, and kept in a phial with ground stopple. But in the *humid way*, the liquor, or lie, of soap-boilers, is heated with a half of its weight of sulphur; till it acquires a deep dark red colour; and is kept, after being filtrated, &c. The difference between these and the common livers, made of mild alkali, is very sensible; these last are of a paler colour, sometimes they are greenish, and always less odorous. It seems that the aerial aid, which they retain, weakens their strength.

The earthy, and saline earthy substances, have no action on the *liver of sulphur*; but the acids precipitate the sulphur in a fine white powder, called the *Magister sulphuris*: and the
gaa

It is found

a. Pellucid, of a deep yellow colour.

b. Opaque, white, and greyish [*d*].

These

gas it disengages, is the above mentioned *Hepatic air* of Sect. 230.

Sulphur, nitre, and charcoal, when well mixed together in a proper proportion, form the well-known detonating substance, called *gun-powder*. One hundred pounds of that made at *Essone*, near *Corbeil* in France, contains 75 of nitre, 9 and a half of sulphur, and 15 of charcoal; but in general one pound of gun-powder contains 12 of nitre, 2 of sulphur, and 3 of charcoal. The opinion of producing, as is pretended, gun-powder without sulphur, is quite groundless. The moisture necessary for the powder's assuming the grained form, crystallises the nitre, as may be seen with a magnifier by cutting the grains through. It is owing to the *dephlogisticated air*, disengaged from the nitre, that the combustion of gunpowder is attended with so great a detonation and violence.

The *fulminating powder* is composed of 3 ounces of nitre, two of dry aerated salt of tartar, and one of sulphur, well triturated in a warm marble mortar, with a wooden pestle. About a drachm (60 or 72 gr.) of it in an iron ladle, over a gentle fire, detonates with such a report as that of a cannon. Also a mixture of *liver of sulphur*, with the double of nitre, detonates with equally as great a report. *Editor from Fourcroy.*

[*d*] *c.* Crystallized, in octoedral prisms, with blunted points.

d. Transparent. Mr. Davila had been informed that this was brought from Normandy in France. *Brun.*

1. Native sulphur is found in different forms, viz. either in solid pieces of indeterminate figure, running in veins through rocks; or in small lumps, in gypsum and lime stones; in considerable quantities at *Solfatara*, and in the neighbourhood of volcanos; or crystallized in pale, transparent, or semitransparent, octogonal, or rhomboidal crystals, in the cavities of quartz; and particularly in the matrices

496 INFLAMMABLE SUBSTANCES. Sect. 253.

These are found in Siberia, at Beviex in Switzerland, and at Solfatara near Naples.

It is often found on lime-stone, which the vi-
triolic acid has left untouched, having a stronger
attraction to the phlogiston, and therefore wholly
uniting with it.

matrices of ores : or in the form of small needles over
hot springs, or near volcanos. *Kirwan.*

Sometimes it is formed in old privies ; of this I saw some
lumps that were found in a very old privy at Paris, *Editor.*

2. United with clay in the aluminous ore of *La Tolfa*, and
also at *Tarnowitz*, in Silesia. This last resembles a light
grey earth : when dry, bursts, or cracks, in the water,
like marl ; and possesses a strong peculiar smell like cam-
phor. If distilled, the sulphur sublimes.

100 parts of this earth afford 8 of sulphur, besides gypsum,
and a quantity of iron.

3. Mixed with *clay*, iron, and *selenite*. This compound is
of a grey, brown, or black colour, found near *Rome*,
Auvergne, *Spain*, and *Iceland*.

4. With lime-stone in the form of a *calcareous hepar*. This
is found at *Tivoli* near Rome, and elsewhere in Italy.
It is sometimes dissolved in mineral waters ; *three pounds*
of which contain as much as 25 *grains* of sulphur. It
often forms incrustations on the brinks of these springs.

5. *In the form of an alkaline hepar*. This is said to be
found in some waters in Russia : of this will be spoken in
Sect. 255.

6. United to Iron and clay of pyrites, &c. of which here-
after, Sect. 254.

7. United to metallic substances, as in Sect. 257 and 258.
Editor chiefly from Kirwan.

SECT.

S E C T. 254. (152.)

B. Sulphur that has dissolved, or is saturated with, metals. *Sulphur metallis saturatum* [a].

1. With iron, *Sulphur marte saturatum*.

Pyrites, or Copperas-stone, *Pyrites*.

This is the substance from which most sulphur is prepared, and is therefore ranked here with all its varieties. It is hard, and of a metallic shining colour.

a. Pale yellow Pyrites, *Pyrites subflavus*.

Marcasite.

This is very common, and contains a proportionable quantity of sulphur with respect to the iron; when once thoroughly inflamed, it burns by itself.

1. Of a compact texture, *Texturâ æquali*, called *Piedra del Ynca*, in Spain.

2. Steel-grained, *Texturâ chalybeâ*.

3. Coarse-grained, *Texturâ granulâtâ*.

4. Crystallised, *ChrySTALLISATUS*.

It shoots mostly into cubical and octoedral figures, though it also cristallises into innumerable other forms [b].

S E C T.

[a] Sulphur is the most common mineralizer of metals, and therefore most of its combinations, with those substances, must be ranked among the metallic ores. *Edit.*

[b] Of this kind is the *juan blanco*, which should not be thought the same with *platina*, though it comes from the

S E C T. 255. (153.)

b. Liver-coloured Marcasite, *Pyrites colore rubefcente.*

Its colour cannot be described, being betwixt that of the preceding marcasite, and the azure copper ore. When it is of a light colour, it is called in Swedish *Tennbett*, or *Wattnkies*, but *Lefverslag* when it is of a deeper colour. The iron prevails in this kind; it is therefore less fit to have sulphur extracted from it, and also for the smelting of copper ores. It is found

1. Of a compact texture, from Nya Kopparberget, in the province of Westmanland.
2. Steel-grained, from Stollberget in Westmanland.
3. Coarse-grained, from Westersilfverberget in Westmanland.

same mines. The crystallized or polish-bearing species are known by the name of *marcasites*. In Hungary, there are some which are pretty rich in gold; in the Moder-mine, near Schemnitz, they held sixteen denari. *Brun.*

S E C T.

S E C T. 256. (155.)

Various Combinations of Sulphur, with Iron and other Metallic Substances.

Sulphur with iron and copper, *yellow or marcasitical copper ore.* (See Sect. 198. of the Author.)

Sulphur with iron, silver, and lead. *Potter's lead ore.* (See Sect. 189. of the same.)

Sulphur with iron and zinc, *mock lead, black jack, or blende.* (See Sect. 229. of the same.)

Sulphur with iron and arsenic, *arsenical pyrites.* (Sect. 243. of the same.)

Sulphur with iron and cobalt. (See Sect. 250 of the same.)

Sulphur with iron and bismuth. (Sect. 225. of the same.)

Sulphur with iron and nickel. (Sect. 256. of the same.)

Sulphur with iron and gold, *pyritical gold ore.* (See Sect. 166. of the same.)

S E C T. 257. (156.)

Other Combinations of Sulphur, with Silver, Copper, and other Metallic Substances.

Sulphur with silver, *glass silver ore* [a].
(See Sect. 169. of the Author.)

Sulphur with copper, *grey or vitreous copper ore*. (See Sect. 197. of the same.)

Sulphur with lead, *Potters lead ore*. (See Sect. 187. of the same.)

Sulphur with bismuth. (See Sect. 224. of the same.)

Sulphur with quicksilver, *cinnabar*. (See Sect. 218. of the same.)

Sulphur with arsenic, *Orpiment, Realgar*.
(See Sect. 241. of the same.)

[a] At *Ramelberg*, and in the *Hartz*, sulphur is extracted from the sulphureous ores of silver and lead, mixed with pyrites, by sublimation, during the terrefaction of these ores. This forms *crude sulphur*, which is purified by a second sublimation. But in *Bohemia* and *Saxony* it is obtained by immediate distillation from pyrites, and afterwards purified by sublimation in close vessels. Most of the sulphur used here comes from Italy. *Kirwan*.

S E C T.

S E C T. 258. (161.)

Mineral Phlogiston mixed with Metallic Earths.
Phlogiston minerale metallis impregnatum.

This is not found in any great quantity.

In regard to its external appearance, it resembles pit coal; and the fat substance contained in it, at times, partly burns to coal, and partly volatilizes in a calcining heat.

The only known varieties of this kind are,

A. Minera cupri phlogistica.

When it has been inflamed, it retains the fire, and at last burns to ashes, out of which pure copper can be smelted. It is found in Sladkierr's Grufva in the province of Dal, and at Bitperg's Klack, in the province of Dalarne.

B. Minera ferri phlogistica.

This is not very different in its appearance from the pit-coal or fossil pitch; but it is somewhat harder to the touch; there are two varieties of this species;

1. Fixt in the fire, *Minera ferri phlogistica fixa.*

Exposed to a calcined heat, it burns with a very languid though quick flame: it preserves its bulk, and loses only a little of its weight. It yields above 30 per cent. of iron.

a. Solid, resembles black sealing-wax.

K k 3

It

502 INFLAMMABLE SUBSTANCES. Sect. 258.

It is found in the liver-coloured marcasite (Sect. 252), in Waskberget, at Norrberke, in Westmanland.

- b.* Cracked, and friable, from Finnberget, at Grythyttan, in Westmanland.

2. Volatile in the fire, *Minera ferri*
phlogistica volatilis.

This is unalterable in an open fire, either of charcoal in a furnace, or even upon a piece of charcoal with the flame of the blow-pipe: but, under a muffel, the greatest part of it volatilizes, so that only a small quantity of calx of iron remains. It is found,

- a.* Solid, from Kronprint's Shurff, at Kong-
sberg, in Norway.

- b.* Cracked, from the parish of Quistbro, in the province of Nerike.

This last kind leaves more ashes: these ashes, when farther exposed to the fire, become first yellowish-green, and afterwards reddish-brown, when, besides iron, they then also discover some marks of copper. It has, however, not been possible to extract any metallic substance from them; the effects of the load-stone, and the colour communicated to the glass of borax, having only given occasion to this suspicion.

*See the end of Sect. 239. (or Sect. 150.
of the Author.)*

S E C T. 259. (162.)

Observation on Bitumens.

That substance, which the chemists call *Phlogiston*, or an *inflammable principle*, exists in most of the mineral bodies, though often in so small a quantity as not to be perceived; and therefore I have here only enumerated those kinds, in which it exists as a principal or very sensible character; as, for instance, in the foetid spar, or swine stone.

I do not myself know the substance in its simple state, which I call a *mineral phlogiston* [a], since the ambergrise and the rock-oil are nothing else than compositions which cannot be perfectly decomposed; and are not, besides, to be extracted from coal, sulphur, &c. which, notwithstanding, contain an inflammable substance. It seems as if a great part of this class were originally generated from the animal and vegetable kingdoms; so that they have been first an *humus ater* or mould, with which a vitriolic acid has afterwards been mixed; and that they have been best able to retain this phlogiston, when they have been covered and

[a] We may say, however, at present, that phlogiston may be produced almost pure, after the new observations and discoveries that have been made of late on the aeriform substances. See Note [a] to Sect. 229. Page 441.

pressed together by another earth; the *coal*, *coal ore*, and *peat turf* (Sect. 193 of the Author), give some hints or reasons for this supposition.

The generation of sulphur and marcasite, requires no phlogiston out of any of the kingdoms of Nature in preference to the other; for the phlogistons throughout all nature are equally fit to compose it [b].

It is a sublime subject for philosophers to enquire, how far fire, phlogiston, and electricity, have an affinity with, or dependence on, one another; but as they yet want that light in this matter, which they wish to have, I hope to be excused for not mentioning any theories on the subject.

This class is of great use in medicine; for instance, the ambergrise, the salt of the yellow

[b] All fossils, containing phlogiston in such abundance, that, under proper management, are inflammable, have been referred to this third Class of Minerals. The Orders are obviously very few; and, accurately speaking, there is only one Genus. But since phlogiston is so very subtle, as not by itself alone to become the object of our senses in its pure state, it has been advisable to consider its more simple combinations as Genera: and this has long been done, so far as respects the metals, by universal consent.

The name of *Sulphur* may certainly be given to any *acid*, coagulated by *phlogiston* into a solid form; and, if metals consist of certain radical *acids*, saturated with *phlogiston*, as is highly probable, and, with respect to *arsenic*, and two others, is indubitably proved (See the Note to page 510.), then metals ought to find a place in this Class. But until this theory be established by numerous experiments, we have only ranked, under this head, the compounds which have not a metallic nature. *The Editor, chiefly from Bergman's Sciagraphia, Sect. 132. and following.*

Sect. 259. INFLAMMABLE SUBSTANCES. 505

amber, the rock-oil, the asphaltum, and the sulphur. The rock-oil and sulphur are used in fireworks; the asphaltum [c] by the cement-makers, and the yellow amber is used by the varnishers and painters, [d].

[c] The first English Edition says, that the Asphaltum is made use of by *watch-makers*; but this must be a real mistake, as it is obviously absurd to suppose that any advantage can be reaped from any oily substance, which soon volatilizes, and is even corrosive itself: when the greatest difficulty our watch and chronometer-makers labour under, is to find a very thin and fluid oil, which may be applied to the pivots of the wheels, and to the palets of the escapements, without thickening, nor condensing by cold, nor drying by length of time. Such kind of oil is a great desideratum in watch making, and the asphaltum has quite the opposite qualities. It may, however, be usefully employed in making a durable cement of the best sort, as Bomare asserts. *The Editor.*

[d] The coals in particular are of the greatest consequence for oeconomic uses; and happy therefore are those countries which have a sufficient quantity of them; since they may be employed as fuel to almost every purpose, as is plainly proved in England. *Engestrom.*

CLASS

C L A S S . IV.

Metallic Substances.

S E C T. 260. (163.)

General Properties of Metals [a].

METALS are those mineral bodies, which, with respect to their volume, are the *heaviest* of all hitherto known bodies. Some

[a] Those metals, which in a calcining-heat lose their phlogiston, and consequently with that the former coherency of their particles, are called *imperfect*, as *tin*, *lead*, *copper*, and *iron*, and all the *semi-metals* (of which more hereafter): notwithstanding which they may be *malleable*. But those which cannot be destroyed in the fire alone, are called *perfect*, as *gold*, *silver*, and *platina del Pinto*. Nevertheless, the metals have commonly been considered more with regard to their *malleability* than to their *fixity* in the fire, and are therefore divided into,

A. Malleable, which are called *metals*; and

B. Brittle, which are called *semi-metals*.

The *zinc* is, however, as a medium between these two divisions, just as the *quicksilver* is between the *perfect* and *imperfect* metals; because the *quicksilver* may indeed be so far destroyed in the fire, that its particles are separated

Some of them are *malleable*; and some may be

separated during their volatilization; nevertheless, every one of them, even the minutest, retains the phlogiston united with it. *The Author.*

Zinc and arsenic stand also, as it were, upon the borders betwixt *metals* and *inflammables*; for these, in proper circumstances, burn with a very evident flame.

All the metallic substances contain phlogiston, and when, to a certain degree, deprived of it, fall into a powder like an earth; but their attractions for phlogiston are different.

Most of them, when melted in a common way, and exposed to the air, have an earthy crust formed upon the surface, which cannot again be reduced to metal without the addition of some inflammable matter. The *base metals* have this property.

But the *noble metals*, viz. *platina*, *gold*, and *silver*, are so firmly connected to the phlogiston, that they never calcine under fusion, however long continued; and, after being changed into a calx in the liquid way, when melted in the fire, they re-assume their metallic form, without any other phlogiston than what is contained in the matter of heat.

Quicksilver holds a kind of middle place; for, like the *base metals*, it may be calcined, though not readily; and like the *noble ones*, it may be reduced by heat alone.

Bergman's Sciagr.

We may therefore reckon four *noble* or *perfect metals*; viz. *gold*, *platina*, *silver*, and *mercury*; because, when calcined, they recover their phlogiston, without the addition of any phlogistic substance.

But as *tin*, *lead*, *copper*, and *iron*, cannot be reduced without such addition, these are called *Ignoble* and *Imperfect*, or *base metals*.

However, all these eight metals (even mercury, when solid) are *malleable* to a considerable degree, and are called *intire metals*. But

Bismuth, *zinc*, *antimony*, *arsenic*, *cobalt*, *nickel*, *manganese*, *mo'ytdena*, and *wolfram*, are scarce at all malleable, and hence they are called *Semi-metals*. Nevertheless, *zinc* and *purified nickel*, are more malleable than any of the other
semi-

be *decompounded*; and, in a melting heat, be brought

semi-metals; so that we have four *perfect* or *noble* metals; four *imperfect* or *base*; eight *intire*; and nine *semi-metals*.

Kirwan.

The various degrees of heat required, to reduce metals to a fluid state, are seen in the following table, which was extracted, for the most part, by Dr. Withering, from the printed Treatises of the late celebrated Professor Bergman. It exhibits, in a simple view: 1. The *specific gravity* of each metal: 2. The *degree of heat* by Fahrenheit's scale, in which it melts: 3. The quantity of *phlogiston* it requires for its saturation: and 4. its *affinity* to the same *saturation* *phlogiston*. We must, however, observe, that if the second column be compared with that of Wedgwood's thermometer, already mentioned in the Note to page 230 of this Mineralogy, their great disagreements betray some fundamental error in the assumed data; as the degrees of heat, assigned by Mr. Wedgwood, for melting *gold*, *silver*, and *copper*, are more than quadruple of those assigned by Bergman, and that for melting *iron* is more than *eleven* times greater; although they both nearly agree in the *red heat* of *iron*, which Bergman says to be 1050 degrees, and Wedgwood 1077. As far as I can judge, the fault lays in Mortimer's thermometer, which Bergman quotes with some diffidence (Sect. 197. of his *Sciagraphia*): probably the changes caused by heat, on this metallic thermometer, are in a much less increasing proportion by intense fire, than those indicated by the contraction of the *pure clay*, happily employed by Wedgwood in his thermometer. I have therefore added another column to this table marked *Wedgw.* with the degrees of the melting heats already ascertained by this last thermometer, as being the nearest to truth. The curious may fill up the vacancies whenever they please, as these new thermometers can now be had for three pounds sterl. each, at the Inventor's Ware-house, London.

N. B. Metallic Thermometer of Mr. Crom. Mortimer, is compleatly described by himself, in the vol. of the *Phil. Transact.* for 1747, p. 684. *The Editor.*

METALS.

Sect. 260. METALLIC SUBSTANCES. 509

brought back again to their former state, by the

M E T A L S.	Specific Gravity.	Melting Heat. Berg.	Melting Heat. Wdgw.	Saturating Phlogiston.	Attraction to saturating Phlogiston.
Gold	19,640	1301	5237	394	1 or 2
Platina	21,000			756	1 or 2
Silver	10,552	1000	4717	100	3
Quicksilver	14,110	—40	—40	74	4
Lead	11,352	595		43	10
Copper	8,876	1450	4587	312	8
Iron	7,800	1601	17977	342	11
Tin	7,264	415		114	9
Bismuth	9,670	494		57	7
Nickel { common }	7,000	1301		156	11
{ pure }	9,000	1601		109	5
Arsenic	8,308				
Cobalt { common }	7,700	{ 1450 1601			
{ pure }					
Zinc	6,862	699		182	11
Antimony	6,860	809		120	6
Manganese	6,850	very great		227	11

N. B. By *saturating phlogiston*, Professor Bergman means to express the proportionate quantities taken away from each metallic substance, when dissolved by means of acids, and of course reduced to a calciform state. The last column only expresses their attraction to this part of their phlogiston, not to that which still remains united to them in a calciform state.

Withering.

The great similarity between *metallic* and *inflammable* substances, has been mentioned in Note [a], to Sect. 228. p. 433. But metals in general are opaque bodies, whose specific gravity exceeds 5000, as the lightest of them are above six times heavier than an equal bulk of distilled water. They consist of heavy, dull, brittle earths, combinable with phlogiston, and whilst so combined, possessing a shining appearance.

Kirwan and Bergman.

Mr. Mongez remarks, that the following are the general properties of metals, when considered as *physical bodies*; viz. their *opacity*, great *specific gravity*, *ductility*, *tenacity*, *crystallization*, *flavour*, and even *smell*, at least in some of them.

It

the addition of the phlogiston they had lost in

It is from their *density* that their *gravity* and *opacity* proceed; this last being such, that even reduced to the thinnest plates, no rays of light can pass through their particles, unless there remains an interstice, or pore, quite free from the metallic substance. Gold leaf must, however, be excepted, which exhibits a fine green by transmitted light. See Note [d] to Sect. 261.

As to their *crystallization*, it has been found to take place, whenever they are pure, and left to cool very slowly by themselves, after having been perfectly fused. See Journal de Physique, for July 1781, p. 74. The *flavour* and *smell* above-mentioned, are very sensible in the reguline substances of *arsenic* and *antimony*, as well as in *lead*, *copper*, and *iron*. The Editor.

All metals are conductors of electricity; and more perfectly so than any other bodies, during their union with phlogiston.

They are soluble either in nitrous acid, and in dephlogisticated marine acid, or in *aqua regia*; and are precipitable in some degree by caustic alkalies; and, except platina, by the Prussian alkali.

When dephlogisticated, they communicate a tinge to *borax*, and to *microcosmic* salt, or at least render them *opaque*.

They assume a convex surface, when melted; and even a globular form, if in a small quantity; and though they mix, for the most part, with one another, whilst fused, yet they refuse to unite with unmetallic substances, even their own calces, iron only excepted, which does to its own calx *slightly dephlogisticated*, and to *plumbago*. Nickel also, and some others, may contain *sulphur* in their reguline state.

Metals, when calcined, are capable of uniting with other calces and salts.

Three of the metallic calces have been found to be of an acid nature; viz. the *arsenical*, *molybdenic*, and *tungstenic*, from which, by analogy, the nature of other calces may be conjectured.

The phlogiston, contained in metals, is in a pure state; viz. without *water* and *aerial acid*, with which it is invariably accompanied in all other compounds, except *acid airs* and *sulphur*. The Editor, chiefly from Kirwan.

When

their decomposition.

When metallic substances are naturally found in the earth, united to their full share of phlogiston, and consequently possessing their peculiar properties, they are called *native*.

But when they are found more or less deprived of their phlogiston and of their properties, combined with other substances, they are then called *mineralized*. This is the most common state of the mineral kingdom. The substance so combined with them is called the *Mineralizer*; and the whole is called *ore*; by which name are also distinguished the *earths* and *stones*, in which metallic substances are contained.

But if both metallic substances are mixed together in their *metallic* or *reguline* form, without the loss of *phlogiston*, they are then said to be *alloyed*.

When the *mineralizer* is of a *saline nature*, and renders the metallic combination soluble in less than 20 times its weight of water; the compound is ranged among *salts*. Thus the *vitriols* of iron, copper, and zinc, are rather classed with *salts*, than with *ores*.

The commonest mineralizers are *sulphur*, *arsenic*, and *fixed air* (or *aerial acid*). The least common are the *vitriolic* and the *marine acids*. The *phosphoric* has been found only in two instances; *viz.* united to *lead*, discovered by Gahn; and to *iron* in the *siderite*, as Mr. Meyer believes.

Those metallic substances, mineralized by *aerial acid*, are called *Calci-form ores*. The Editor, chiefly from Kirwan.

If the new doctrine of Mr. Lavoisier and his followers, who pretend that calces of metals are a compound of *dephlogisticated*, or *vital air*, with the metallic substance, were any ways probable; all *calci-form ores* should produce this *vital air*, instead of *aerial acid*, when they are reduced to their metallic-form, which is not the case; neither should all the *base metals* and *semi-metals*, absolutely require the mixture of some phlogistic substance, for being reduced from the state of calces to their metallic form, which otherwise would be quite useless, if their reduction simply consisted in their separation from the *vital* (the dephlogisticated) *air*. See the Note [*] to page 442.

The Editor.

ORDER

ORDER THE FIRST.

Noble or Perfect Metals.

S E C T. 261. (164.)

Gold, *Aurum. Sol Chymicorum*, Lat. Or, French.

THIS substance is esteemed by mankind as the principal and first among the metals; and that partly for its scarcity; but chiefly for its following qualities.

1. It is of a yellow shining colour.
2. It is the heaviest of all known bodies, its specific gravity to water being as 19,640 to 1000.
3. It is the most tough and ductile of all metals. One grain of it may be stretched out so as to cover a silver wire of the length of 98 *Swedish ells*, by which means $\frac{1}{105,600}$ of a grain becomes visible to the naked eye [a]

4. Its

[a] According to Pauſton, 98 Swedish ells make only 63,66 English yards, (2291,76 English inches); but, as the *hundredth part* of one inch is visible enough to the naked eye; and we may conceive, that every one of these minute cylinders can be seen by rays of light reflected from six different parts, at least, of its surface, the Noble Author might safely assert,

4. Its softness comes nearest to that of lead,
and

assert, that above one millionth part of a *grain* of gold; (*viz.* $\frac{1}{1000000} = \frac{1}{1000000}$), is visible to the naked eye.

But Wallerius goes still further, unless there be some error in the press; for he says (page 352. vol. II. edit. 1778), *parum etenim aurum pondere unius grani ad 500 ulnarum longitudinem extendi posse.*

Halley, quoted by Apligny (p. 152. of his *Treatise on Colours*), says, that *one ounce* of gold ($= 576$ grains) is enough to cover 48 *ounces* of silver, which may be drawn so fine, without leaving the silver naked, that 6 feet of it shall not weigh above *one grain*. Then *one grain* of gold may cover a wire of 294 feet, or 98 yards; and $\frac{1}{1000000}$ of one grain, may cover $\frac{1}{2}$ of one inch, which divided into 10 parts, every one of them will be very visible without any magnifier: from thence it is evident, that $\frac{1}{1000000}$ of *one grain* of gold is very discernible to the naked eye, in each single side of its surface.

Boyle, quoted also by Apligny, says, that one grain and a half of gold, may be beaten into 50 leaves of one inch square; which, if cut by parallel lines, drawn at the distance of $\frac{1}{100}$ of an inch from one another, will produce 25 millions ($25000000 = 5000 \times 5000$) of little squares, very discernible to the naked eye.

The ductility of gold is such, that it may be extended, by the hammer, 159092 times its surface.

I am informed, by an intelligent gold-beater in England, that the finest gold leaf is that made in new skins, and must have an alloy of 3 *grains* of copper to the *ounce troy* of pure gold, or else it would be too soft to pass over the irregularities of the skins. He affirms, that 80 books, or 2000 leaves of gold, each measuring 3,3 square inches; *viz.* each leaf containing 10,89 square inches ($= 3,3 \times 3,3$), weigh less than 16 *dwt.*, or 384 *gr.* ($= 16 \times 24$ *gr.*). Each book, therefore, (or 25 leaves $= 272,25$ square inches) weighs less than 4,8 *gr.* ($= \frac{1}{10}$); and each *grain* will produce 56,718 square inches ($= \frac{10,89}{2000}$).

and consequently it is but very little elastic [b].

5. It is fixed and unalterable in air, water, and fire, because it does not easily part with its phlogiston; its liquid menstruum (7) being only made by art.

It has, however, according to Homberg's experiments, when exposed to Tschirnhausen's burning-glass, been found partly to volatilise

Now one cubic inch of pure gold weighs 10,359 ounces Troy, or 4972,32 gr. ($480 \times 10,359 \text{ oz.}$); and of course, one grain of gold, when beaten into a square surface of one inch, only occupies, by its thickness, the $\frac{1}{497,32}$ part of the inch side of this cube; but as each grain produces above 56,718 leaves of this dimension, it is evident that the thickness of each leaf is in fact less than the $\frac{1}{36,718 \times 497,32}$, or $\frac{1}{18,162}$ part of an inch.

By the above treatment, the 16 dwts. of gold are made to cover 151,24 square feet; since the 16 dwts, or 384 gr. produce 21779,712 ($= 384 \times 56,718$) square inch leaves, 144 of which make a foot square. But, when silver is covered with gold, and drawn into a wire, the gold may spread over its surface 12 times more, without leaving any space uncovered, that may be seen, even with a deep magnifier; thus, 16 ounces of gold, which, if in the form of a cube, would not measure one inch and one quarter on its side, will completely gild a quantity of silver wire sufficient to circumscribe the whole globe of the earth. *The Editor, from Wallerius, Reaumur, Nicholson, Pauson, &c.*

[b] Gold is more elastic than lead or tin; but it has less elasticity than iron or copper. *Fabr.*

However, when hammered, it becomes harder. *Bomare.*

It has not only a ductility greater than any other metal, but the tenacity or cohesion of its particles exceeds that of others. A wire of gold, not thicker than the tenth of an inch of the Rhine foot, can hold 500 pounds weight, without breaking. *Wallerius and Bomare.*

in

in form of smoke, and partly to scorify; but this wants to be farther examined. (See Sect. 264.) It is also said that gold, in certain circumstances, and by means of certain artifices in electrical experiments, may be forced into glass; and that on this occasion it becomes *white*, leaving a *black dust* behind it [c], which, if so, confirms certain other chemical experiments; viz. that gold can, together with its colour, lose something of its phlogiston, and yet retain its heaviness, ductility, &c.

6. When melted, it reflects a bluish-green colour from its surface [d].

7. It

[c] This must be a mistake of the English Editor, unless the author has been himself grossly misinformed. It is true, that fine gold is intimately (though not uniformly) united to, or forced into, a glass surface, by the electrical explosion; even some part of it becomes calcined, producing fine purple spots on the glass, as I have seen sometimes: and Dr. Priestley asserts the same, in his *History of Electricity*; but the metal never turns *white*, nor does it leave behind any *black dust*, if it is pure. *The Editor.*

[d] When gold is exposed to fire, it becomes red-hot long before it melts: in this case it has a brilliant greenish colour, inclining to blue; and, when cold, crystallises into quadrilateral pyramids. *Mongez.*

I have said, in the note to page 510, that gold-leaf exhibits a fine green colour, by transmitted light, a fact which every one may easily verify; and the same phenomenon takes place, when the metal is ignited, as just now observed. The green light is transmitted in both cases, since all reflected colours are produced by the transmission of light, as the ingenious Philosopher Mr. Delaval has lately discovered and demonstrated,

7. It dissolves in *aqua regia*, which is composed of the acids of sea-salt and nitre; but not in either alone, nor in any other solution of salt or acid whatsoever. [e].

8. When

in his very elaborate Treatise upon this subject, *inserted in the second vol. of the Memoirs, published in 1785, by the Philosophical Society of Manchester*. Sir Isaac Newton, in his Opticks (page 162, edition of 1730), accounts for that phenomenon, saying, that *gold foliated, and held between the eyes and the light, looks of a greenish blue; and therefore, says he, massy gold lets into its body the blue rays, to be reflected to and fro within it, till they be stopped and sifted, whilst it reflects the yellow outwards, and thereby looks yellow*. It is therefore in the two above cases, that some of the *blue rays* are transmitted along with the *yellow ones*, and both together appear of a *green bluish colour*, since every one knows, that blue and yellow together make a green colour. If gold be exposed to the joined rays of light, except only the *yellow ones* (which we suppose stopped after they were separated by a prism), it only looks *white like silver, which shews*, says Sir Isaac Newton (p. 166.), *that its yellowness arises from the excess of the intercepted rays tinging that whiteness with their colour, when they are let to pass*.

It is a pleasing observation to look with a deep magnifier on various pieces of *gold, silver, and Dutch (copper) leaf*, between the eye and the sun-shine. The particles of *Silver* are seen in the form of oblong dark lumps, with some interstices, like net-work, between them: those of the *copper leaf* are more numerous and more regularly distributed; but the particles of the *gold leaf* appear like little green semi-transparent and similar particles, joining between themselves by nearly diaphanous joints, as if they were forced to flatten in their edges, rather than they would break their mutual union between one another. *The Editor*.

[e] Gold is not only dissolved in *aqua regia*, but also in the *dephlogisticated marine acid*. As to the pure concentrated

nitrous

8. When mixed with a volatile alkali and a little of the acid of nitre, by means of precipitation out of *aqua regia*, it burns off quickly, in the least degree of heat, with a strong fulmination. (See Sect. 264.)
9. It is dissolved, in *forma sicca*, by the liver of sulphur, and also somewhat by the glass of bismuth [f].

nitrous acid, it rather tears, or corrodes the particles of gold, than makes with it any real solution, since it is enough to shake it, to free the metallic particles from the acid, and cause them to fall to the bottom, as *Wallerius* and *Mongez* assert. See Note [y] to page 289. The Editor.

By distilling vitriolic acid from off manganese, an acid is obtained, which alone is capable of dissolving gold, silver, and mercury, very readily, as Dr. Crell affirms in a letter to Mr. Darcet. Journ. de Physique, Oct. 1785, p. 297.

The solution of gold in *aqua regia* is accompanied with effervescence; is of a yellow colour more or less deep; tinges animal substances of a deep purple colour, and corrodes them. Its causticity is considerable: after a proper evaporation, it gives yellow crystals; if these are distilled, produce a fine red liquor, to which the Alchemists gave the name of *Red Lian*. Fourcroy.

[f] Neither sulphur, nor fixed alkali, have any action on gold; but the liver of sulphur, which is a compound of both, can dissolve it in the dry-way; so that if a proper quantity of gold leaves is put in a crucible, together with liver of sulphur, and it is melted in a brisk fire, the gold is thoroughly dissolved; and if the whole is diluted in water, the gold will be kept in the solution, and even pass through the filtre along with it.

Gold, as well as silver, is so much attenuated by bismuth, that it may be advantageously employed in their coppellation, as Keir asserts in his notes to *Macquer's Dictionary*; but Poerner, quoted also by the same Author, in his second edition, is of a contrary opinion. The Editor.

10. It is not carried away by the antimony during the volatilisation of that semi-metal, and is therefore conveniently separated from other metals by the help of crude antimony, in which process the other metals are partly made volatile, and fly off with the antimony, and partly unite with the sulphur, to which the gold has no attraction, unless by means of some uniting body, or by a long digestion [g].
11. The phosphorus is said to have ingress into gold [b].
12. If mixed with a small proportion of silver, platina, copper, iron, and zinc, it preserves its ductility tolerably well; but,
13. When mixed with tin it becomes very brittle; and it attracts likewise the smoke of

[g] Antimony is used also to refine gold from its alloy, as it attenuates and carries off all other metallic substances mixed with it, without excepting the silver; whilst lead leaves this last behind, and even adds some of its own to the gold. *Pauclon, p. 639.*

[b] Gold, reduced into thin leaves, is not acted upon by the phosphoric acid in the *humid way*, though the fire be urged till luminous decrepitations take place; but when it passes that point, which separates the *humid* from the *dry way*, Mr. Margraff observed, that some purple scoria were formed, which is an indication that this concrete acid had partly calcined the gold during its fusion. *Elements de Chymie de Dijon, Vol. III. p. 131.*

Besides this, a drop of the phosphoric acid on the solution of gold by *aqua regia*, precipitates the metal in its revived state, as asserted by the same Academicians of Dijon. See Note [b] to p. 314. *The Editor.*

that

- that metal, so as to be spoiled, if melted in an hearth where tin has been lately melted [i]. And this is perhaps the reason why gold becomes brittle, and of a paler colour, when melted in a new black lead crucible [k].
14. It requires a strong heat before it melts, nearly as much, or a little more than copper.
 15. It mixes or amalgamates readily with quicksilver [l].
 16. It is not dissolved by the glass of lead, and therefore remains on the cuppel.

In consequence of these its principal qualities, it seems as if gold could never be found in the earth, but in a native or pure state; there are, however, several instances where it has been found dissolved or mineralised [m]

[i] The fumes only of a single grain of tin are capable of rendering hard eight ounces of gold; but it easily recovers its malleability by being melted on the fire. *Wallerius* and *Beccari's Mineralogy*.

But when gold is mixed with *arsenic*, *cobalt*, *nickle*, *bismuth*, or with the *regulus* of *antimony*, it only loses great part of its malleability; and when in a certain proportion, it may be calcined and vitrified with them. *Fabroni*.

[k] The Author supposed (in the first edition) that *black-lead* contained *tin*; but late experiments shew, that it does not contain any. See *Deff.* 231. If the fact, asserted by the Author, is constant, it must proceed from some other cause.

The Editor.

[l] There is a very peculiar and strong attraction between gold and mercury; and it seems to be greater than that between the *lead-stone* and *iron*. *Wallerius*.

[m] Those instances, mentioned by the Noble Author, as proofs of gold being found *mineralised*, are disputed by some eminent Mineralogists, though upon doubtful grounds, as will appear by the Sect. 263. *The Editor.*

S E C T. 262. (165.)

A. Native Gold, *Aurum nativum*.

Is in its metallic form *commonly* pure; and in this state most part of this metal used in the world is found [a]. With respect to either,

[a] This must be a mistake of the editor of this work, as it is well known that native gold is generally found impure. Bergman openly acknowledges not to know that it has ever been found perfectly pure: and Kirwan only allows that it is seldom found so, being generally alloyed with *silver*, *copper*, or *iron*, or all three. As to the gold, commonly used in jewels and other objects of luxury, every one knows that it is purposely debased, by the artists, with copper or other metals; and of late it has been employed in various pieces of jewellery, forming ornaments of various colours; as a great alloy of *silver* (viz. one-third part) gives it a shade of a green colour; a similar quantity of copper, a *reddish* one; a mixture of arsenic, or filings of steel, in the proportion of one-fourth part, gives it a *blueish* cast; so that having the *yellow* naturally in the pure gold, and the *white* in pure silver, the jewellers have almost all the colours to diversify their work.

Even in the currency of money, there is none coined out of pure gold, which, by common agreement, is called *gold of 24 carats*. The gold coin of England, France, and Portugal, only contains 22 parts of *pure gold*, and 2 of alloy; viz. it is only of 22 *carats*, in the common saying; that of Spain is but of 21 $\frac{1}{2}$ carats; but the *ducat* of Holland is of 23 $\frac{3}{4}$ carats; and the *zucchino* of Venice, of 23 $\frac{1}{2}$ carats: this last is the purest gold coin, as it seems, of Europe at least. *The Editor, chiefly from Pausan's Metrologic,*

the

the figure or the quantity in which it is found in one place, it is by miners divided into [b].

1. Thin superficial plated or leaved gold, which consists of very thin plates or leaves, like paper [c].
2. Solid or massive, is found in form of thick pieces [d].

3. Cryf-

[b] Wallerius distinguishes native gold by the following 6 forms; viz.

1. In *solid* masses; found in *Hungary*, *Peru*, and *Transylvania*.
2. In a *granular* form, found in the Spanish West-Indies.
3. In a *vegetable* form, like branches or twigs of plants.
4. In a *drusic* figure, as if composed of *groups*, or clusters of small particles united together; found in *Hungary*.
5. In a *superficial* form, composed of thin plates, or thin pellicles covering other bodies, found in *Siberia*.
6. And crystallised, found in *Hungary*.

Finally, Mr. Daubenton, in his *Methodical Tables of Minerals*, enumerates 8 sorts of native gold; viz. 1. in powder. 2. in grains. 3. in small spangles. 4. in masses or lumps. 5. in filaments. 6. in branches like vegetables. 7. in lamellæ; and 8. in octoedral crystals.

The same Natural Historian says also, that gold, in its reguline state, is either 1. formed into angular crystals, composed of yellow octoedres; or 2. into irregular yellow masses, which, being broken, shew a granular substance. *The Editor*.

[c] Native gold in a form of leaves, is always crystallized on its surface.

These crystals are very small: with a microscope, one may discover their triangular pyramidal form.

In Transylvania, I have procured a specimen of cubic native gold, but never saw it any where else.

The crystals on the stone, are of the size of small hemp-seeds. *Brun*.

[d] Gold is in general more frequently imbedded and mixed with quartz, than with any other kind of stone; and the quartz in which the gold is found in the Hungarian gold mines

3. Crystallised, consists of an angular or crystalline figure [e].

4. Wash gold, or gold-dust, is washed out of sands, wherein it lies in form of loose grains and lumps [f].

SECT.

mines, is of a peculiar mild appearance. All other sorts of stones, however, are not to be excluded; since gold is likewise found in some of them; for instance, in lime-stone (Sect. 9.) in Adolph Fredrik's Grufva at Adelfors, in the province of Smoland; in Hornblende (Sect. 137.), in Bastna's Grufva at Riddarhyttan, in the province of Westmanland; not to mention several foreign gold mines.

The greatest quantity of gold is imported into Europe from Chili and Peru, in America; and a little from China, and the coast of Africa. The chief European gold-mines are those of Hungary, and next to them that of Salzburg. Besides these, there are some others of less consequence; among which the gold-mines at Adelfors in Smoland deserve to be taken much notice of, not only on account of the veins already worked, but also in regard to the vast tract of land, within which new veins are daily discovered. The silver, from the mines of Osterfilvarberget, in the province of Dalarna, contains from 4 to 7 grains of gold in the mark. Some native gold has likewise been found in Swappawari, above Tornea in Lapland, and in Bastna's, near Riddarhyttan, in Westmanland. *The Author.*

[e] The crystalline form of gold is the *oblong rectangular one*, for the most part; but it is also found in the form of small *drusical crystals*; sometimes branched like *dendrites*, and sometimes solitary. There are also cubic crystals of this metal (Note D), all which evidently show how little can we trust to the test of crystalline forms, in order to distinguish mineral substances from one another. *The Author from Wallerius, Romé de l'Isle, &c.*

[f] Wallerius distinguishes this kind of gold by the various earths and substances with which it is mixed; and by the different colours it assumes from them as the *ochreous*, *margaceous*,

margaceous, and *argillaceous* gold ores; those mixed with *red granatic sand*, or with *black and lead-coloured sand*, &c.

Native gold is found also *separate*, from any matrix in lumps, or visible grains mixed with sand; and in this state it is found in many rivers of *Europe*, *Africa*, and elsewhere, or visibly dispersed through large masses of sand, particularly the yellowish red, or violet; and, in this state, it is so generally diffused through all species of earth, though in exceeding small quantities, that Mr. *Bergman* thinks it more universally found than any other metal, except iron. If 100 pounds of sand contain 24 grains of gold, it is said the separation is worth attending to; but in *Africa* 5 pounds of sand often contain 63 grains of gold, or even more; the heaviest sand, which is often black or red, yields most. In *Hungary*, 10,000 pounds of sand yield but 19 or 12 grains of gold; it was extracted, but with loss. *Born's Letters from Hungary*, quoted by *Kirwan*.

Most great rivers carry gold with them; even such as do not take their rise in those mountains where gold is found; it is therefore no wonder, that all rich gold-mines enrich their rivers with this metal.

The river *Avanyos*, in *Transylvania*, affords subsistence to upwards of 700 gipsy families, who collect the gold from it.

In *Brazil* the gold is found in so great abundance, that their torrents are often driven, with very considerable labour and expence, to new beds, in order to gather the gold there deposited by the running waters. But it is also found there mingled within the earth in various shapes and forms.

In *Peru* gold is found with a stony matter, not well known, and a red earth, from which it is there extracted by amalgamation with mercury. *The Editor, chiefly from Kirwan.*

The celebrated Naturalist, Mr. *Pallas*, speaks in the Account of his Tour through *Siberia*, of three gold mines that are worked there, near the river *Pyckhma*, in which 500 men are employed. The gold is found in a powdery form, and also in thin small plates, or leaves. Sometimes kernels, or lumps of a spongy texture, and very light, are met with, in which a good quantity of gold-dust is loosely contained. The ore it found in a white clay, though, for the most part, it is of a grey yellowish colour, intermixed with mica. An argill, of a fine red colour, is also found in these mines. It was near them

S E C T. 263. (166.)

B. Mineralized Gold, *Aurum mineralisatum*.

This is an ore, in which the gold is so far mineralised, or enveloped by other bodies, as not to be acted on by the aqua regia.

1. Mineralised with sulphur, *Aurum sulphure mineralisatum* [a].

2. Mineralised

them that the red lead-ore, described by Leheman, was discovered. But these Siberian mines do not seem to produce above 400 marks of gold in the year, and could not pay the expences of being worked in a less cheap country than Siberia. See *Journal de Physique* for June 1783. *The Editor*.

Wolkemann, quoted by le Camus, asserts, in his *Solterra-neous Silesia*, that gold is also found, sometimes in veins, running through beds of coals. *Journ. de Physique*, for March 1779, page 183.

And Mr. Eller of Berlin, had, in his Collection, an ore, which contained gold, silver, iron, and quicksilver, closely united together in the same mass. Watson's Chemical Essays, Vol. IV. p. 157.

[a] Since gold and sulphur have no attraction to one another, many have insisted, that gold never can be found in marcasite, or those ores which contain sulphur: but since we know by experience, that gold can be melted out of the above-mentioned Ores, although they have been previously digested in aqua regia; and that gold likewise enters into their sulphurated regulus; there is the greatest reason to believe that a third substance, which here is a metal, must necessarily have, by its admixture, enabled the sulphur to unite with a certain quantity of gold. Scheffer has given upon this subject some very curious and useful observations, in his History of the Refining of Metals, inserted in the Transactions of the Academy of Sciences at Stockholm. It is very remarkable, that the Mine-

Master

2. Mineralised by means of iron. *Aurum sulphure mineralisatum mediante ferro.*

Marcasitical gold ore. *Pyrites aureus.*

It is found at Adelfors, in the province of Smoland; and contains one ounce of gold, or less, in an hundred pounds [b].

3. Mineralised

Master Henckel, author of that excellent Treatise *de Appropriatione*, should be so obstinate in denying that marcasite could contain a dissolved gold.

It is, however, by no means hereby intended to confirm the credulous in their opinion, that the marcasites in general contain more gold than what true metallurgists have asserted; because fraud might then perhaps become too common. It is only meant to indicate, that, as no gold is to be expected from marcasites, where no native gold is found in the neighbourhood; in the same manner no marcasites ought to be despised, which are found in tracks where gold ores are dug; but at the same time care must be taken not to be deluded by the mention of volatile gold, as it is a notion really contradictory and suspicious, and then there can be no fear of being misled.

I am not perfectly clear, whether the gold is really dissolved and indurated, or, if I may so express myself, vitrified in the Shirls (Schirlkornern), provided by this mineral body is meant a garnet substance (Sect. 68. of the Author). But I have seen a piece of what is called *Shirl*, whose texture was exactly like the Schemnitz blende; and, in this case, it might perhaps hold the same contents (Sect. 175. of the Author). For the other gold ores, I have not had an opportunity of seeing any from those places where gold is searched for and really found. *The Author.*

[b] This Pyrite is of a bright yellow colour, close and compact. The gold in this ore is said to be *mineralized* by sulphur, by means of iron, because it cannot be extracted by *aqua regia*, or by amalgamation. *Kirwan.*

3. Mineralised by means of quicksilver, *Aurum sulphure mineralisatum mediante mercurio*, auriferous cinnabar. It is said to be found in Hungary [c].

4. Mineralised

It is well known, that gold may be dissolved by *liver of sulphur*; the following is the process given by Apligny (p. 156. of his *Traité de Couleurs*).

Pound *four pounds* of vegetable alkali (salt of tartar), and as *many* of sulphur, with *one* of leaves of gold; melt the mixture in a crucible with its cover; pour the fused matter on a marble; pound it again when cold, and put the whole in a matrafs, with hot water; which, being filtrated, is of a yellow greenish colour, containing the gold dissolved. Now, as we know that *hepar sulphuris* has been found in several pyrites, and Mascagni asserts (p. 279. of his *Commentario*) to have found it in those of the lagoons near Sienna, in Italy; is it not very natural to conclude, that this noble metal may be really mineralized in the auriferous pyrites? *The Editor*.

The Transylvanian gold pyrites, in which no gold can be discovered by the eye, hold from 50 and 100, to 110 ounces and upwards, in an hundred weight. Those, where the gold appears in the pyrites, like strewed Spanish snuff, hold 250 ounces, but they are very scarce. The mountain of *Faczchaya* near *Zalatna*, is remarkable for its gold pyrites; they seem likewise to contain semi-metallic parts. *Brunnich*.

[c] Mr. Sage, quoted by his two great admirers, Messieurs Romé del Isle (p. 420. Vol. I. of his *Cryсталlogie*), and Dr. Demeste (p. 466. of his *Letter* 44.), speaks of a specimen of gold from Hungary, now in the French King's cabinet at Paris, which is crystallized into quadrangular prisms, of a grey-yellowish colour, and of a brittle consistency. This Mr. Sage asserts to be the result of a mercurial amalgam of native gold. *The Editor*.

They sometimes find quicksilver in the shafts of the mines of *Michael* and *Siglisberg*, near *Schemnitz*; but the people have no idea of its containing gold, which may be the case, if it were well separated. It is most probable that the other Hungarian cinnabars contain none; but I shall be able to

4. Mineralised by means of zinc and iron, or silver. *Aurum sulphure mineralisatum mediante zinco & ferro, aut argento.* The Schemnitz blende [d].

At Schemnitz, in Hungary, are found zinc ores, which contain a great deal of silver, and this silver is very rich in gold. See Sect. 175. of the Author.

SECT.

speak of this with more certainty, after I have made trials with them. Brunnich,

[d] Wallerius speaks of two kinds of this ore; one, the *Pseudogalena aurifera rubens*, found in Schwarzenberg mine of Saxony; and the *Pseudogalena aurifera nigrescens*, which is reckoned amongst the silver ores, the gold being in a very small quantity, found at Schemnitz, in Hungary.

But Professor Brunnich, in his notes to this Section, enumerates the following varieties of mineralized gold ores; viz.

5. Mineralized by means of a cubic lead-ore containing silver. From the mines of Michaeli, and some shafts in Transylvania.

6. Mineralized by means of a copper pyrites, with silver. Is called *gils* in Hungary; has a compact pale yellow surface, and must not be confounded with gold pyrites.

7. Mineralized by means of red gilder-ore. The *Granit-ores*.

8. Mineralized by means of antimony, in which it sometimes appears. From the mountains of *Magarea* or *Margara*, near *Deutschblitz*, at the foot of the Carpathian mountains.

9. Mineralized by means of cubic lead-ore, iron, and unknown volatile parts. From Nagyai, near Deva, in Transylvania. Scopoli describes this ore in his third *Annus Historico Naturalis*, as follows; Its colour is black; the richest pieces are lamellated almost like an iron-glimmer, with a degree of flexibility. The vein is quartz, which is sometimes loose, and wherein the ore is very minutely scattered.

10. Native gold, with black-lead (or molybdana), has been broken near *Rimnembat* in Upper Hungary; but whether it has been mineralized with it, I have had no opportunity of examining.

In

S E C T. 264. (Additional.)

Observations on Gold, and its mineralizations.

Gold is justly called the *King of Metals*, as it is the most ductile, malleable, heavy, and unalterable of all metals. When exposed to air, immersed in water, or buried in the earth, suffers neither decomposition in its substance, nor rust, or even change of colour in its surface, although the dust, or apposition of external particles, may disguise its lustre ; but, on being

In all the above species, the gold is either intirely native ; but so minutely divided, and so loosely scattered, that it can only be seen through microscopes, and often cannot be seen at all, before it is separated by various processes ; or it may not be in form of native gold, but as a gold as it were in embryo ; in which case fire is necessary, in order to bring the constituents parts together, and to add those that are wanting ; in that case likewise it is never without silver. *Brunnich.*

To the above may be added the following ores ;

11. Gold, with *arsenical pyrites*, is found also at *Saltzberg* in *Tyrol*, in mountains of quartz and shistus. It contains only 25 grains in the quintal ; and, nevertheless, this mine affords a profit of 500 pounds *per annum*.

12. With a *white, red, or vitreous silver ore*, near *Cremnitz*, and *Schemnitz*, in Hungary.

13. With a *fulphurated ore of silver, iron, lead, and manganese*, at *Nagaya* in *Transylvania*. Its specific gravity is = 4,043. It is said to afford 10 ounces per quintal.

14. With *fulphurated iron, copper, and manganese*, at *Nagaya*. *The Editor*, from *Kirwan, Mongez, Bomare, &c.*

washed

washed off, it appears as bright as before; and when exposed to the most violent fire, is quite fixt, without suffering calcination, nor sensible change or loss in its mass.

Messieurs Boyle and Kunkel kept gold constantly fused in a violent heat, during two months, and found not a single grain to have been lost. It is true, that when exposed to the focus of a large burning lens, it is evaporated, but without changing its metallic state. The late celebrated Professor Macquer shewed me, at Paris, a plate of pure silver, which he had exposed to that visible atmosphere, which surrounded the said melted gold; and, by means of a magnifier, numberless particles of the gold could be very well discerned as attached to its surface. This accounts for the assertion of Mr. Lavoisiere, in the *Memoires* of the *Academy of Sciences* at *Paris*, for 1782, who says, that gold, when exposed to the flame of a lamp, blown by a current of dephlogisticated air, (which is the most violent degree of heat that has ever been produced, and is one of the most important modern discoveries) is intirely volatilized, without leaving behind the least mark of calcination.

However, Mr. Kirwan observes, that on exposing gold to the focus of that most powerful lens, made by Mr. Parker, in London, for some hours continuance; although it lost no sensible part of its weight, yet, when in contact with earthy matters, it communicated a blue or purple tinge to them; from whence it

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appears

^appears that some minute, though insensible portion of it, was really dephlogisticated.

If a solution of gold in *aqua regia* be properly mixed with that of tin dissolved in the same menstruum, a fine *purple powder* is precipitated, called by the name of *Cassius*, its inventor, which produces the finest lasting purple colour. This powder, mixed with vitreous substances, is employed preferably to any other, by encaustic painters and glass-manufacturers. The late famous Chymist, Mr. Macquer, describes, with great accuracy, in his Dictionary, various processes to obtain, with certainty, this precious calx of gold.

If volatile alkali is added to the same solution of gold by *aqua regia*, a reddish yellow powder is precipitated, which is the *aurum fulminans*. It is also commonly made, by dissolving gold in a kind of *aqua regia*, made with *nitrous acid* and *sal ammoniac*, from which the *fulminating gold* is afterwards precipitated by the fixed alkali. A few grains of this powder detonate with a prodigious noise. When exposed in a metallic spoon or plate, over a candle, coals, or a red hot iron; or when, by other means, it is sufficiently heated, its fragor is 64 times greater than an equal quantity of gun-powder.

A degree of heat, as between the 120 and 300° (at which the nitrous and vitriolic acid boil) is sufficient to produce this amazing explosion, by which the most violent effects are produced. *Ten or twelve grains*, exploded on a metal-plate, perforate and lacerate it; and a few ounces, having

having exploded together, by incautiously drying it, have shattered the doors and windows of the apartment.

Even simple triture, or percussio alone, is enough to cause this powder to explode with all its violence, by which dreadful accidents have sometimes happened. Macquer relates the case of a young man of his acquaintance, 22 years old, who shutting up a small bottle of crystal, with about a dram of this powder, some little of it, between the stopple, was kindled by twining it: the bottle burst into pieces, by which he was violently struck, fell to the ground, and his eyes were quite shattered, so that he remained irrecoverably blind. And it is remarkable, that the greatest part of the contents in the bottle did not detonate, a quantity of them being found unaltered and dispersed in the room. Professor Bergman has published a very elaborate dissertation on this *fulminating powder*, in the second vol. of his *Opuscula*; but this wonderful phenomenon seems not yet compleatly accounted for in any hypothesis as yet known, nor even in that proposed by the celebrated Scheele, in his *Treatise on Fire*, Sect. 82. as he supposes there what seems not at all admissible; viz. that the *matter of heat* is a compound of *phlogiston* and *dephlogisticated air*. See Note [f] to page 347. of this *Mineralogy*.

It is on account of the singular and excellent natural qualities of this metal, which are considerably heightened by its scarcity, that gold

is so much valued among all the civilized nations of the world, as the Noble Author said in Sect. 261. Mr. Pauſton, in his *Metrologie*, p. 94. ſays, that one cubic foot (French meaſure) of gold, is worth 2153000 *livres tournoises*, or 89708 *guineas* and 7 *ſhillings*; ſuppoſing the *louis d'or* equal to the *guinea*; and that the reſpective value of the ſame *cubic foot* of gold, is equal to 25,6 cubic feet of ſilver, each of this laſt metal being reckoned worth about 84080 *French livres*, or 3503 *guineas* and 8 *ſhillings*; ſo that if we ſuppoſe the monied ſpecies in *France* to be but two *milliards* of *French livres*, according to the eſtimation of Mr. Necker, in his treatiſe upon the *Commerce of Corn*, the whole amount ſhould make but a ſolid cube of gold, leſs than *ten feet* on each ſide. So trifling is the phyſical object that excites the activity of 22 millions of the human ſpecies, the number that is ſaid to be that of the inhabitants of *France*!

As to the natural exiſtence of gold in the bowels of the earth, there have been two oppoſite opinions among Mineralogists; ſome pretending, that it is only found in its *metallic* or *native form*; and others, that it is ſometimes found *mineralized*, in an intimate union with other mineral ſubſtances. The famous Profeſſor Bergman was among thoſe of this laſt opinion; but Mr. Kirwan holds the firſt, and ſays, that although Mr. Bergman inclines to the opinion of the mineralization, yet he is candid enough to own, that the gold, when extracted from this
ore,

ore, is of a granular, or angular form. It is therefore, says Mr. Kirwan, very doubtful whether it was not rather *mixed*, than truly *combined*, with the sulphur and iron: and its proportion being exceedingly small, so that one hundred pounds of the pyrites contain hardly one ounce of gold; it is not a wonder, that it should escape the action of *aqua regia*; more especially, as the nitrous acid becomes so phlogisticated, by acting on the pyrites, as not to be able to dephlogisticate the marine. Likewise Mercury, by the circumstantial accident of the gold particles being enveloped, or surrounded by the sulphureous iron, can have no access to it.

These arguments against true mineralization of gold, are fully answered by those facts, and reasonings, expressed by the Noble Author in the preceding Sect. 263, and in its notes. Besides, it is well known, that gold can be combined and calcined *via siccā*, by the *liver of sulphur*, and some semi-metals, as has been said in the same Notes. This being acknowledged on both sides of the question, why should we insist in denying this mineralization, when it is out of doubt, among all Mineralogists of rank, that volcanic fires have had a great share in the convulsions and revolutions of this globe, of which every one has the most convincing proofs almost every where? The account given by Mr. Hacquet [*a*],
of

[*a*] By this account of Mr. Hacquet, it appears that gold is found mineralized; *viz.*

1. By *sulphur*, zinc, and arsenic, in a grey-yellowish volca-

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of the gold mines at Nagy-Ag, in Transylvania, the ancient Dacia, which lies about 45 *degrees* of latitude, offers the most convincing proofs of this assertion. The country all round these mines, bears an incontestable appearance of being a volcanic one; and among various other metals, there are found at least 13 kinds of gold-ores, most of them mineralized. *The Editor.*

S E C T.

nic ore, which is called *Cottoners* (or Cotton-ore), on account of its lightness and texture.

2. By iron and arsenic, formed by strata, one containing black silver ore, then spatum, galena, quartz, and grey gold ore: it gives about half an ounce *per cent*.

3. By sulphur, antimony, zinc, some arsenic, and sometimes iron; this is a grey gold-ore mixed with quartz.

4. In form of crooked threads, mixed with quartz and gypseous spath: it is a poor mine.

5. Dendritiforme, like the mocho-stone, or the agate from Aberstein, in the Palatinate, but these black dendrites are in a reddish stone,

6. A morpheous very compact in small grains, with spath and quartz: it gives two ounces of gold, and more of silver, *per quintal*.

7. By sulphur, great part of zinc, and little of antimony and arsenic: not a rich ore of gold.

8. Of a black, or dark reddish colour, containing an auriferous pyrites, not rich.

9. Of a blueish colour, mineralised by sulphur, antimony, iron, and a little arsenic, mixed with silver; very rich in gold.

10. Partly laminated with needles of a blackish yellow colour; this gives 66 oz. *per* $\frac{2}{3}$ of gold according to Scopoli.

11. Foliated with gypseous spath, and yellow pyrites.

12. In irregular lamina, on a greyish argille. The gold looks like silver, and is surrounded by spars of a pale rosy colour.

13. In

S E C T. 265. (167.)

2. Silver, *Argentum, Luna*. This Metal is

1. Of a white shining colour [a].

13. In crystallized lamina, from 2 to 4 lines diameter, of an hexangular form; it is very much like the *molybdene*. Professor Brunnich, on this account, calls this ore, but improperly, *minera auri martialis pictoria*. The vein has been lost a long while; but a new branch was lately met with, on mining for letting out the water from the main. This ore is very rare, and has given 372 ounces, *per* 2 of noble metal, 5 parts of which were gold, and one silver. *The Editor from Journal du Physique, for January 1785.*

[a] Silver, called *Luna* or *Diana*, by the alchemists, is a perfect metal, the whitest and of the most vivid brilliancy among them all.

Its surface, however, *tarnishes*, and becomes of a *dark brown* colour, when exposed to *hepatic*, or phlogistic effluvia (N° 10.). If rubbed on a paper, or on a chalky white surface, it leaves *bluish* marks. Its calx being precipitated by volatile alkali, gives a *yellow* tinge to glass (*See Gellert's Metal. Chym. p 301.*): and I have seen some stained with it of so high a colour, as to appear quite *red*. Mr. Macquer, by exposing the same silver, 20 times, to a very violent fire, found some little vitreous calcinations of an *olive* colour. And by melting silver with *gold*, or *steel*, in a due proportion, it assumes a *greenish*, or a *bluish* colour; so that this noble metal is capable of producing the *white, yellow, red, green, blue*, and *olive* colour, more or less conspicuously, according to the various circumstances of heat, and proportions of the mixture.

Fourcroy says, that silver has neither *smell* nor *taste*, when pure. But its diluted solution has a particular disagreeable taste, very different from that of other metals.

Silver is so fixt by itself in the fire, that, after being kept a whole month in fusion, it had only lost one 60th part of its weight, which might be on account of some alloy. It is therefore incapable of being calcined by mere heat; and the calx of silver, which can only be made by means of its solu-

2. Its specific gravity to water is as 11,091 1000 [b].
3. It is very tough or ductile, so that a grain of it may be stretched out to three Swedish ells, of 2 feet each, (or 5 feet 8 inches English measure), and two inches in breadth.
4. It is unalterable in air, water, and fire.
5. It dissolves in the acid of nitre, and also by boiling in the acid of vitriol [c].

6. If

tion in acids, is reducible to its metallic form, without the addition of any phlogistic substance.

But when silver is exposed to the violent heat of the solar rays, collected by a powerful burning lens, a kind of smoke is seen surrounding it, which proves at last to be the minute particles of the metal raised and dispersed by heat; as is evident, if a thin plate of gold is exposed to it, on which surface they may be seen with a magnifier. This is the same phenomenon which was observed on gold, when in similar circumstances. See page 529.

If it is slowly cooled, after having been fused, it crystallizes into octoedral figures, though seldom perfectly so: for the most part it only shews the half of them, appearing like so many quadrilateral pyramids. *Editor chiefly from Wallerius, Fourcroy, Bomare, Mongez, &c.*

[b] Its specific gravity, according to Bergman, is = 10,552; but, according to Kirwan, it is = 11,095. See the Note [b], to Sect. 295. *On the causes of variation of the specific gravities of bodies.*

A cubic French foot of Silver weighs 720 pounds of *French weight*, according to Macquer. As to its relative value, see p. 532.

Silver is harder and more elastic than *lead*, *tin*, or *gold*; but is softer than *iron*, *platina*, or *copper*. It stiffens under the hammer, but becomes soft by nealing: and is the most sonorous of all pure metals, except copper.

A silver wire, a tenth of an inch thick, may support, without breaking, 270 pounds weight, according to Macquer, Fourcroy, and Bomare; but Wallerius carries it farther, unless there be some typographical error, saying, it may hold 370 pounds,

6. If precipitated out of the acid of nitre with the common salt, or with its acid, it unites so strongly with this last acid, that it does not part from it, even in the fire

370 pounds; and asserts, that a vessel may be made so thin of this metal, without being heavier than a single *grain*, which will hold a cubic inch of water.

[c] Silver requires nearly twice its weight of nitrous acid to be dissolved; this is it's most specific menstruum; even cold, it attacks silver with a considerable effervescence, grows hot, and emits a large quantity of vapours of an orange colour, which diminish in proportion as the saturation advances.

The metal looks of a pale brown colour in the conflict; and the solution becomes quite black; but I have observed, that this last appearance was owing to a thin black fuliginous substance, like smut, which was at once formed into a crust on the surface of the thin plates of silver, in the first attack of the acid upon them. This black substance is a very singular phenomenon, which I know not how to account for. These black crusts being comminuted into smaller and smaller particles, by the intestine motion of the effervescing acid, produced the black appearance of the whole; and, when it was over, they were very distinctly seen to fall to the bottom of the vessel, and to form a black sediment, leaving the liquid solution quite transparent, but of a blue colour inclining to green, which last might be attributed to some small mixture of copper, altho' the silver was of the pure kind, myself having bought it as such, from one of our best refiners, at *Foster lane* in *London*.

The Chemists of Dijon only say, that the nitrous solution of silver looks of a fine blue colour, if the acid is pure and well concentrated; but if it has any mixture of vitriolic or marine, a precipitate of *vitriolated silver*, or of *luna cornea*, takes place. Afterwards the solution becomes as colourless as water; but gives a lasting black-purple tinge to animal substances.

This solution is of great use in chemistry; and, in particular it serves to purify the *nitrous acid*, or *aqua-fortis*,
from

fire itself, but melts with it into a mass like glass, which is called *luna cornea* [d].

7. It

from the mixture of the *vitriolic* and *marine acid*, which are often mixed therewith; as, by pouring in it little by little a few drops of it, these two acids are precipitated, and the nitrous afterwards is decanted in a pure state. The same solution, diluted in distilled water, is a very nice test to discover any vitriolic, or marine part, contained in Mineral Waters.

The nitrous solution of silver, when properly evaporated, produces a large quantity of white crystals, of a scaly form; some are hexagonal, and some of an octoedral figure, which are called *Lunar Crystals*. This salt is fusible in a moderate fire; loses its water of crystallization; becomes black, and is very corrosive; on account of which quality it is cast into small cylindrical moulds, and is known under the name of *Lapis Infernalis*, as its use is to corrode the spongy flesh of sores, &c. According to Mr. Scheele, the dark colour of this caustic substance proceeds from the alloy of copper, for even the refined silver, by the common method, contains some of this metal. See at the end of the following note [d], the best method of purifying silver.

The nitrous solution of silver may be decomposed by *earthy*, *saline*, and *metallic substances*; and, when the decomposition is made by *mercury*, a very curious precipitate takes place, which, by its similarity to vegetables, is called *Arbor Diana*.

Aqua regia dissolves very well this metal, but it is immediately precipitated, forming a *luna cornea* with the muriatic part of this solvent. The Editor, chiefly from the Elements of Chemistry of Dijon, and Fourcroy.

[d] The marine acid attracts the calx of silver, but cannot remove its phlogiston; and therefore cannot dissolve it in its metallic state. *Bergman*.

However the marine acid, if well concentrated, or rather reduced into an aerial form, dissolves silver in its metallic state. *Fabroni*.

Mr. Scheele, and after him Mr. Bertholet, assert positively, that the marine acid, being dephlogisticated by its distillation over manganese, in the form of a yellow air or gas, dissolves

7. It does not unite with the semi-metal *nickel*, during the fusion.
8. It amalgamates easily with quicksilver.
9. It is, in the *dry way*, dissolved by the *liver of sulphur*.
10. It has a strong attraction to sulphur, so as readily to take a reddish-yellow or black colour, when it is exposed to sulphureous vapours.
11. It has no attraction to arsenic; whence when the red arsenical silver ore, or *Rotbgulden Ertz* of the Germans, is put into the fire, the arsenic flies off, and leaves the sulphur (which in this compound was

dissolves all the metals, without excepting *gold*, *silver*, nor *mercury*. See *Scheele's Essay* 5, §. 25 *H*.

The vitriolic acid, being distilled also over the manganese, dissolves *silver*, *gold*, and *mercury*, as Dr. Crell asserts. See *Note [e]* to page 517.

Silver is precipitated from the *vitriolic* and *nitrous acids* by the *marine*; and from the *nitrous*, in great measure, by the vitriolic. *Kirwan*.

The silver extracted from *luna cornea*, is purer than can be made by cupellation, and is the only one to be trusted to in the nicest operations of chemistry. But the process, to free it from the *muratic acid*, is very tedious, and presents a very unexpected phenomenon, as this metal, though one of the most fixed kind, is nevertheless so volatilised thereby, that it escapes through the pores of the crucible; and small globules of silver are found afterwards in the cover, and even in the support of the crucible. According to Cramer, this loss may be prevented by smearing the crucible with *black soap*, and mixing to the *luna cornea* half its weight of oil or tallow, which last must also be added, little by little, during the operation. See *Elem. de Chimie, de Dijon*, Vol. II. p. 221.

the

the *medium uniens*) behind, united with the Silver in form of the glass-silver-ore, or *glass ertz*.

12. It is not dissolved by the glass of lead, and consequently it remains on the cuppel.

13. It is exhaled, or carried off by *volatile metals* and *acids*, as by the vapours of *antimony*, *zink*, and the *acid of common salt*.

14. It melts more easily than copper [e].

S E C T. 266. (168.)

Native Silver.

Silver is found,

A. Native or pure, Argentum purum nativum.

Native silver most generally is nearly of sixteen carats standard [a]. It is found

[e] This was a general opinion, *viz.* that silver required a less degree of heat than copper to be melted in the fire, as the noble author asserts; but the contrary appears, by the nice thermometer lately invented by Mr. Wedgewood, as may be seen by the note to page 230. This new instrument is one of the most valuable acquisitions of modern date, for all kinds of processes, and philosophical disquisitions in metallurgical, chemical, and various other operations of art by fire; all which were till now regulated only by guess, without any fixed standard to ascertain the real degree of heat belonging to each. *The Editor.*

[a] In the first edition of this Mineralogy, corrected by the late Dr. Lewis, use is made of the word *lots* instead of *carats*; and it is added, that native silver never is fully of 16 *lots*; which last is called the *Fine Mine of Silver*. By this it seems to be meant, that *native silver* is found nearly free, but never fully so, from *all base metals*, as *copper*, *lead*, &c. *The Editor.*

1. Thin

1. Thin superficial, plated or leaved.
2. It is also found in form,
 - a. of snaggs, and coarse fibres.
 - b. Of fine fibres. Capillary silver.
 - c. Arboresecent. From Potosi in America, and Kongsberg in Norway [b].
 - d. Cristaline or figured. This is very scarce to be met with: it has distinct figures, with shining surfaces; it is, however, sometimes found at Kongsberg [c].

The silver from America is said to be found for the most part native; so it is likewise at Kongsberg in Norway [d].

It

[b] Sometimes silver is found, the surface of which resembles coarse linen, or what is called *knit cobalt* in Saxony; it is so found abundantly in Potosi, rarely at Saxony, and at Kongsberg; perhaps our author has reckoned these figures among the *dendritical forms*. Brun.

[c] There appears likewise a kind of crystallization on the thin plates of *native silver*, their surface being full of minute pyramidal crystals, in the same manner as the thin plates of gold which have been mentioned before. Brun.

[d] A good deal of it likewise breaks in Saxony among other rich ores. Brunnich.

Wallerius distinguishes the *native silver* into the following species; viz.

1. In *irregular masses and lumps*, found at *Kunberg* in Norway, and at *Neumarken* in *Wermeland*, where it was in a bed of clay.
2. *Granular*, and in a jagged form, at *Potosi* and *Mexico*, in Spanish America; and at *Kunberg*.
3. *Dendritiform* and *arboresecent*, in the same places, and at *Schneeberg*.
4. In *thin leaves* between the fissures of stones, as at *Kunberg*, *Freiberg*, *Johangeorgenstadt*.

5. In

It is not commonly so in other European mines. In Sweden it is found native in a very small quantity, in the mines of Sälberg in Westmanland, of Løfåsen in Dalarne, of Hevassvik and Sladkierr in the province of Dal, of Sunnerfskog, in the Province of Smoland, and in the island Utoen in the Lake Malaren.

It was once found in pretty large lumps in a vein of clay, in one of the iron mines at Norrmork, in the province of Wermeland. It was there mixed with nickel, which was partly decayed or withered; and under this circumstance it formed the compound ore called the *Stercus Anserinum* or goose-dung ore (See sect. 282.) At this place the argillaceous vein crosses the veins of the iron ore, and will perhaps be found to have more of these riches, even in several other places, if well searched, as is done in other countries, oftentimes not on such evident marks or signs [e].

SECT.

5. In a capillary form, at Schemnitz, in Hungary; at Freiberg, and at Marienberg, in Saxony. Of this kind is the Cobweb silver ore of the Spaniards.

6. In a crystallized form, at Kunsberg, and at Sainte Maria in Alsatia.

7. Superficial, at Salberg, and Løfåsen.

Mr. Daubenton reckons eight varieties of *native white silver*, arising from their peculiar forms: but he reckons separately some of the above forms. *The Editor.*

[e] The Mineralogical Academy at Freyberg, has some *native silver* in coal; this is shewn there among the Kunsberg pieces. *Brunnich.*

And Lehman, quoted by le Camus (Journ. de Physique, for March 1779, p. 183), speaks also of a similar *silver ore*, found in a mine of peat-coal. *The Editor.*

S E C T. 267. (additional).

Native Silver, mixed, or alloyed, with other metals.

Native silver is seldom found pure, viz. by itself alone. The following are the known instances of these alloys :

1. Native silver, united to gold, *Bergman's Sciagraphia* §. 154. That which is found

Native silver is found in various forms, as already mentioned, inhering either in *baro-selenite, lime-stone, selenite, quartz, chert, flint, serpentine, gneis, agate, mica, calcareous spar, pyrites, blisins, clay, &c.*

Also in separate masses of various sizes (some of the weight of 60 pounds) in or near the veins of most metallic substances, particularly in *Peru*, and frequently in various parts of Europe; either of a *white, brown, or yellowish* colour.

Sometimes it is diffused through *sand and ochre*; and also in *grey lime-stone* in the Lower Austria; and in a *greenish clay* near Schemnitz; or mixed with *ochre, clay, and calciform nickel.*

It is seldom found *pure*, being generally alloyed with *copper*, and sometimes with a small proportion of *gold, iron, or regulus of antimony*; and sometimes with about 5 per cent. of *arsenic.*

According to Henckel and other Mineralogists, silver, in the capillary form, and in thin scales, is produced by the decomposition of the *red silver mine*: and Wallerius asserts, that if sulphur is mixed in a small heat with silver, this last takes a capillary form.

At *Kunzberg*, and at *Sainte-Marie-aux-mines*, in Alsace, silver is found in the form of solitary cubes; and octoedral lumps, of 50 and 60 pounds weight, have also been found in the last of these two places. *Mongez.*

of this species near *Königsberg*, contains so much gold, as to acquire a yellow colour from it. *Kirwan*.

2. Mixed with copper. *Berg. Sc.* § 155.
3. United to gold and copper. *Berg. Sc.* § 156.
4. Amalgamated with mercury, found in the mines of Salberg; as J. R. Foster notes to *Brunnick* [a].
5. United to iron. *Berg. Sc.* § 157. The iron in this ore seldom exceeds 2 per cent: but oftner it hardly amounts to $\frac{1}{100}$. *Mongez*.
5. United to lead, sometimes in such quantities, as to be worth the expences attending the separation [b].

6. United

[a] Mr. Romé de l'Isle, speaks of a native amalgam of silver and mercury, now in the French king's cabinet at Paris, which was found (at *Muschel Landsberg*, in the Dutchy of *Deux-Ponts*) in a ferrugineous matrix, mixed with cinnabar. This specimen is of a crystalline hexagonal form, and of a large size. See his *Cryſtallogie*, Vol. I. p. 420. See also the Sect. 287. of this Mineralogy. *The Editor*.

[b] Silver is always contained in lead, though it is generally in so small a quantity, that it is not worth the charges of separating it. Thus, accurate Essayers never fail of trying the lead they use in their coppellations, in order to account for the respective addition arising from it to the neat produce of metal that remains in the coppel. In the reign of Edward the First of England, near 1600 pounds weight of silver were obtained, in the course of three years, from a mine in *Devonshire*, which had been discovered towards the beginning of his reign, viz. about the year 900. The lead mines in *Cardiganshire* have, at different periods, afforded great quantities of silver. Sir Hugh Middleton is said to have cleared
from

7. United to arsenic. Mr. Monnet found this ore among those from Guadanal canal in Spain, as may be seen in the supplement to the *Journal de physique*, for 1778, page 50. The mine of *Samson*, near *Andreaberg* in the *Hartz*, furnishes this species of silver. Mr. Mongez remarks, very properly, that these ores must be distinguished from those in which the arsenic is in the form of an acid; for in this case, they are properly mineralized by it; and such seem to be those of Sect. 170. 235. and 248. of the Author. (See Sect. 275.) Whilst there must be only a mixture with the *native silver*, or with it's calces, if the *arsenic* be in it's *reguline form*.
8. Native silver united to antimony. *Berg. Sc. § 159.* This ore being roasted, gives out some smoke, but has not the smell, similar to that of garlic, which arsenic gives out when burned.

from them 2000 pounds in a month. The same mines yielded, about the year of the Rebellion (1745) *eighty ounces* of silver out of every *ton* of lead. The lead ores from *Brunghill* and *Skekorn* produced also a considerable quantity of Silver. The lead only in one of the smelting houses at *Ho'yswell* in Flintshire, produced no less than 37521 ounces, or 3126 $\frac{1}{2}$ pounds of silver, from the year 1754 to 1776, and from 1774 to 1776. There are some lead-ores in Great Britain, which, though very poor in lead, contain between 3 and 400 ounces of silver in a ton of lead; but it is not to be expected that the Proprietors should be forward in declaring it to the world. It is commonly observed, that the poorest lead-ores yield the most silver; so that a large quantity of silver is probably thrown away in England, from not having the poorest sort of lead-ores properly assayed. *The Editor, from Watson's Essays, Vol. the Third.*

9. Joined to the regulus of arsenic and iron. *Berg.* § 160. This ore is found in the mines near *Freiberg*, where it is called *White-silver ore.* *Mongez.*

The above three metallic ingredients are nearly in equal proportions.

All the species mentioned in this Section have metallic properties and appearances: the contaminating matters are sometimes extremely small; but not to be neglected, when they exceed $\frac{1}{100}$ part of the whole mass. *Bergman*, *ibid.*

10. Native silver mixed with the alkaline lime-stone from *Annaberg*, described by Mr. *Justi*, *Brunnich* [c].

11. Sandy silver ore, without any metallic shining.

11. Silver

[c] Wallerius has formed a particular class of stony silver ores, which he distinguishes by the epithet *Lapidea*, and is the 397 species of his *Mineralogical System*: under this head he describes the following varieties;

1. The *calcareous* silver ore (*argentum alkali mineralisatum*, which seems rather an ambiguous denomination) found at *Annaberg* in Austria.
2. The *spatbose*, or *sparry* silver ore, which is either *white*, *variegated*, or *yellowish*, found at *Schemitz* in Hungary.
3. The *quartzous white* ore, in a powdery form, mixed with ferruginous *Scoria*, found in *Potosi*.

4 and 5. The *dark*, and the *variegated quartzous* silver ores. According to this Author's description, all these ores contain *native silver*, without any material difference, besides the accidental colour, or the mixture of other earths.

It was also for the sake of increasing, as it seems, the number of these useless subdivisions, that this celebrated Mineralogist formed his *Species* 398, containing the *dark-brown*, and the *yellow sandy* silver ores; his *Species* 399 of the *joliaceous*

native

12. Silver ore in a red-brown shistus, described by Lehman: it is composed of argillaceous earth, micaceous hematites, sulphur, calcereous spar, fluor mineralis, lead and silver. It contains about 7 or 8 ounces of silver on the hundred weight.

13. Soft silver ore. It is found among the marles and argillaceous earths, and is of various colours, either singly or mixed. It is somewhat similar to the *goose dung silver ore*: and is found at Marienberg, Schemnitz, Huelgoet, in Brittany, &c. *Mongez.*

S E C T. 268. (169.)

B. Dissolved and mineralised, *Argentum mineralisatum.*

1. With sulphur alone, *Argentum sulphure mineralisatum.* Glass, or vitreous silver ore, *Minera argenti vitrea.*

native silver ore; his Species 401, containing the following soft silver ores; viz. 1. The *ochreous* (or *margaceous*), variegated with *red*, *green*, and *yellow* spots, which is properly the ore that will be described in Section 282: 2. The *yellow*: 3. The *clayish*, unctuous to the touch: 4 and 5. The *solid* and the *porous* margaceous white ore: 6. The *argillaceous*; and, finally, the *copperish* ore, of a *green*, or *blue* colour; and his last article of *Minera argenti figurata*, found in some flates, which he had already described among the *copper ores*.
The Editor.

This is ductile and of the same colour as lead; but, however, becomes black very quickly in the air [a]. It has, therefore,

[a] This kind of ore is found either in large lumps, or inhering in *quartz*, *gypsum*, *gneiss*, *pyrites*, &c.

It is of a *lamellar*, *granular*, or *capillary* form, or *crystallized*.

Though generally of a *lead colour*, sometimes it is *grey* or *black*, even when first broken.

It's lamina are not only ductile, but even flexible, and malleable to a certain degree; and so soft, that they may be cut with a knife.

Its specific gravity is $\approx 7,2000$.

100 parts of it contain from 72 to 77 of silver; and is rarely contaminated with other metal, except some small portion of iron.

It is found in *Hungary* near *Schemnitz*, and in *Saxony* near *Freiberg*, particularly in the famous mine of *Himmelsfurst*. Kirwan.

This ore seems to be nothing else but native silver, penetrated by *sulphur*; for on being exposed to a slow heat, this last flies off, and the native Silver remains in filaments. There are nine varieties of this ore;

1. Like *black-lead*, or *plumbago*, this is the most common of all.

2. *Brown*. Bruckman mentions one of this appearance, which was green in the inside.

3. *Yellow*. This colour is owing to some arsenic contained in it, which forms an orpiment with the sulphur.

4. *Greenish*.

5. *Blueish*. This is friable, like scoria of metals, and is called at *Fryberg* *Schlarckenerz*, ore of Scoria,

6. in form of *vegetations*.

7. *Lamellated*.

8. *Crystallized* into octaedral, or hexaedral prisms, and into decaedral pyramids.

9. *Superficial*; viz. covering the stones, or masses of other ores. *Mongez*.

But Wallerius, by subdividing some of these varieties, has added two more to this number. *The Editor*.

undeservedly

undeservedly got the name of *Glass-ore*; for that name rather belongs to the *minera argenti cornea*, or *horn-silver ore*, if indeed any silver-ore can be considered as *glassy*.

It is found in the same manner as *native gold*, viz.

1. In crusts, plates, or leaves.

2. In the form of

a. Snaggs, and of

b. Crystalline figures.

It is generally either of a lamellar or a grained texture, and is found in Kongsberg and in the Saxon mines, [b].

The *glass-silver ore* is the richest of all silver-ores; since the sulphur, which is united with the silver in this ore, makes out but a very small quantity of its weight [c].

[b] The Hungarian *glass silver-ores* are now scarce; some are now and then found in the wind-shafts, which are very frequently covered with a thin membrane, or rather crust, of the colour of pyrites. *Brun.*

[c] It contains about 180 marks of silver in the hundred weight. The medium between the *glass-ore* and the *red gilder-ore*, is called *Rosch-Gewächs* in Hungary, and *brittle glass-ore* in Saxony. It is of a black colour, and, when pounded, gives a black powder. In the mines of *Himmelsfursts* near Freiberg, it is said to have held 140 marks, but these pieces are very scarce at present. It sometimes shoots into dendritical figures, between the cubic lead-ore, at a mine called *The Old Green Branch* near Freiberg. *Brunnich.*

S E C T. 269. (Additional.)

Arfenico-martial silver ore, *Weill-ertz*
in Germ.

This ore contains *silver* and *iron* mineralized by *arsenic*: this last is in a larger proportion than the *iron*. This is the *Pyrites argenteus* of Henckel.

1. It is a hard substance, of a white shining appearance, and of a compact, lamellar, or fibrous texture.

The brightest has less silver, this only gives 6 or 8 ounces per quintal: and the richest gives about *ten* per centum. It contains no sulphur.

It is found in *Saxony*, the *Hartz*, at *Guadanal-canal*, &c. *Kirwan*, *Spec.* 7.

2. Of a yellowish-white colour, and of a striated structure, resembling *bismuth*, but much harder.

It melts very easily; and, if kept in fusion, it loses it's arsenic, and the silver remains almost intirely pure, as it contains but very little iron.

It produces about 60 *per cent.* of silver.

It is found near *Guadanal-canal* in Spain. *Kirwan*, *Spec.* 3.

3. Near the same place is found also another ore of the same kind; but the quantity of the arsenic in it is so great, that it would scarcely

scarcely deserve to be called a *silver ore*, if the arsenic were not easily dissipated.

It is very soft, and easily cut; and, when cut, has a brilliant metallic appearance. It consists of conchoidal laminæ.

The quintal contains only from 4 to 6 ounces of silver; but

It is easily reduced by evaporating the *arsenic* by fire, which then leaves the *silver* slightly contaminated with *iron*. Kirwan, spec. 4.

S E C T. 270. (170.)

Red or Ruby silver ore. Rothguldén in Germ.

2. With sulphur and arsenic, *Argentum sulphure et arsenico mineralisatum*. *Minera argenti rubra*, The red or ruby-like silver ore. The Rothguldén of the Germans [a].

The

[a] This is a heavy, shining substance, either transparent or opaque; mostly of a *crimson* or *reddish* colour, though sometimes it is *grey* or *blackish*.

It is found either in shapeless masses; or crystallized, in pyramids or polygons; or dendritical, or plated, or with radiated incrustations.

Its matrixes are either the quartz, flint, spar, pyrites, sparry iron-ore, lead-ore, cobalt-ore, jasper, baro-selenite, gneiss, &c.

When radiated, or striated, it is called *Rothguldén bluth*.

It not only cracks in the fire, but detonates with nitre.

Its specific gravity is from 5,400 to 5,684.

N n 4

According

The colour of this ore varies as the proportion of each of these ingredients varies in the mixture; viz. from dark grey to deep red; but when it is rubbed or pounded, it always gives a red colour. When put in the fire, it crackles and breaks; and when the crackling ceases, it melts easily, the arsenic at the same time exhaling in smoke. [b].

a. Grey arsenical silver ore; which is either,

1. Plated, crufted, or leaved, and,
2. Solid.

b. The red arsenical silver ore,

1. Plated, crufted, or leaved.
2. Solid or scaly, and
3. Cryftallifed [c].

In

According to Bergman, it contains in the *bundred*, 60, and sometimes 70 of silver, 27 of arsenic, and 13 of sulphur.

The darkeft coloured ores of this kind are the richeft; and these often contain some little iron. The yellowest are the poorest.

But the most yellow do not belong to this species, being, in fact, an *orpiment*, containing 6 or 7 per cent. of silver.

Kirwan, Sp. 5.

This last kind is called *Rosi-clar* by the Spaniards. It comes chiefly from *Potosi* in America. *Mongez*.

[b] Red gilder-ore, if very well pounded, or ground, turns of a dark colour: cinnabar, under the same circumstances, becomes of a bright red: and orpiment grows yellow. But their crystalline appearance can easily be mistaken. *J. R. Foster*.

[c] Wallerius mentions the six following varieties of this notable ore; in his Species 388; viz. 1. The red opaque, like cinnabar from Andreasberg in the Hartz, and from Salberg in Westmannia: 2. The bluish from Freiberg and Annaberg: 3. The grey from Freiberg and Andreasberg: 4. The red transparent

In this last form it shews the most beautiful red colour, and is often semi-transparent. It contains about sixty per cent of silver; and is found in the greatest quantity at Andreasberg in the Hartz [d].

S E C T. 271. (part of Sect. 171.)

Mineralized by sulphur, little arsenic, and iron.
Schwartz ertz, Schwartz gulden, Silber mulm.
 in Germ.

It is a friable, withered, decayed ore.

a. Of a black or footy colour, and is therefore called by the Germans *Silberschwartz*, or *Rufsigtes-ertz* [a].

S E C T.

parent amorphous, of the garnet colour, from *Potofi* and *Joachimthal*: 5. The red transparent, crystallized into prismatic decaedres, or dodecaedres, from *Hungary*, *Alsace*, and the Duchy of *Deuxponts*: 6. The only superficially red ore, from *Salberg*, and *Ehrenfriedersdorf*. The Editor.

[d] The places where this ore appears very frequently, are *Cremnitz* in *Hungary*, *Joachimsthal* in *Bohemia*, and the *Andreas* mountain on the *Hartz*; and each of these can be distinguished by the different crystallizations. A peculiar variety has been found near *Ehrenfriedersdorf*, in a silver-vein, where it crosses the tin-veins at *Sauberg*. Some of them lose their transparency, especially in damp places. *Brunnich*.

[a] This ore was supposed, by the noble Author, to contain a good portion of copper, to which the black or brown colour was attributed. But later analysis of this substance, have shewn that there is no copper at all, as Mr. Kirwan as-

S E C T. 272. (171.)

Silver mineralized by arsenic and sulphur, with copper and iron.

3. With sulphurated arsenic and copper, *Argentum arsenico & cupro sulphurato mineralisatum.*

ferfs in his Species 6, of which the following is the extract. This ore is either, 1. of a *solid* or *brittle* consistence (which distinguishes it from the *vitreous-ore*) and of a *glassy appearance* in its fracture.

Or 2, of a *looser* texture, and *sooty*, or *deep black* colour.

It is like *moss*, or thin *leaves*, lying on the surface of other silver ores, or of those of *lead* and *cobalt*, or in *clays*, *ponderous spar*, *gneiss*, &c.

This last contains about 25 *per cent.* of silver.

And the former contains at most 60 *per cent.* of silver.

They are found in *Dauphiné*, *Hungary*, and *Saxony*.

Wallerius, in his Sp. 390, mentions the following varieties of this ore; viz. 1. The *spongy* from *Siberia*; and from *Freiberg*, which last produces 50 *per cent.* of silver.

2. That in the *powdry* form, is very rich in silver.

3. The *lamellated*, of a black colour, at *Johan Georgenstadt*, *Freiberg*.

4. That in a *branched* and *dendritical* form, found in *Lorraine*; and

5. The *superficial*, of a black colour, found at *Freiberg*.
The Editor,

In *Hungary* this has the name of *silver mulm*; it has been found at *Wendisch Leuten*, near *Shemnitz*, in *Hungary*, and contains 8 lb. $\frac{1}{4}$ *per cent.* of a silver containing some gold.

Brunnich.

Minera

Minera argenti alba, the *Weissgulden* of the Germans [a].

This, in its solid form, is of a light grey colour, and of a dull and steel-grained texture. The more copper it contains, the darker is the colour. It often holds seven pounds of silver per cent [b].

N. B. The Schwartz silver-ore of the last Section was inserted by the Noble Author in this place. The Editor.

Its texture is solid, of a light grey colour, and is that sort properly called *Weissgulden*.

It is found at St. Mary among the mines in Alsatia, in the Saxon mines, and at St. Andreasberg in the Hartz [c].

[a] Mr. Kirwan says (Sp. 8.), that the *Weissgulden ertz*, or *Weissgulden* ore, is a heavy, soft, opaque substance, fine grained, or scaly, bright and shining in its fractures, of a whitish, steely, or lead-colour; sometimes crystallized in a pyramidical or cylindrical forms; but often in amorphous grains, or resembling moss, or in the form of thin laminæ incrustating other bodies, found in quartz, spar, stellite, pyrites, blend, lead-ore, cobalt-ore, sparry iron-ore, fluors, &c.

It is very fusible.

Its specific gravity is from 5 to 5,300.

Its proportion of silver from 10 to 30 per cent.

It is found, though not commonly, in Saxony, Hungary, the Hartz, and St. Marie aux Mines.

[b] This product of the *Weissgulden*, being so considerably less than what Mr. Kirwan mentions in the last note, justifies the errata, pointed out in Dr. Lewis's copy, in which 20 marks, of 8 ounces each, are put instead of the seven pounds of silver per cent. as mentioned in the text. The Editor.

[c] I have found crystallized white gilder-ore at *Clusshat* in the Hartz, and in *Transylvania*; the last holds above thirteen marks of silver, containing some gold. *Brunnich*.

S E C T. 273. (172).

4. With sulphurated arsenic and iron, *Argentum ferro et arsenico sulphurato mineralisatum*. The *Weisertz*, or *white-silver ore* of the Germans.

This is an arsenical pyrites, which contains silver; it occurs in the Saxon-mines, and so exactly resembles the common arsenical-pyrites, as not to be distinguished from it by sight alone; or without other means.

The silver it contains, may perhaps consist of very subtile capillary silver [*a*] mixed in it.

[*a*] Though our Author suspects that the silver in this ore may arise from subtile capillary silver mixed in it, yet it has not all the appearance of it. It is very scarce, and found with *mispickel* and *plumose silver-ore*, at *Braunsdorf* near *Freiberg*.

There is likewise a *brown mulm*, resembling rags, between and upon the cubic lead-ore, found at the *Dorothea-mine*, in *Clausthal*: this contained a great quantity of silver, but has not yet been tried for any thing else. *Brunnich*.

This ore has a solid and hard consistence, is granulated, and its colour is whitish and shining; it strikes fire with the steel, and discloses then that the arsenic enters into its mass, by a kind of garlic smell; sometimes it contains *native silver*, and this sometimes is *mineralized*.

It is found not only in *Clausthal*, but at *Andreasberg*, *Braunsdorf*, and *Allemont*, in *Dauphiné*. *Mongez*.

N. B. This ore is very different from that of Sect. 269. in which, according to *Monnet*, quoted by *Kirwan*, no sulphur is contained. *The Editor*.

However,

However, I have not had an opportunity to examine this circumstance.

S E C T. 274. (173.)

5. With sulphurated antimony, *Argentum antimonio sulphurato mineralisatum*.

a. Of a dark-grey, and somewhat brownish colour.

The *Leberertz* of the Germans; from *Braunsdorf* in *Saxony*.

b. Of a blackish blue colour.

1. In form of capillary crystals, *Minera argenti antimonialis capillaris*. The *Federertz* of the Germans, or *plumose silver ore* [b].

It is found in *Saxony*, and contains only two or four ounces of silver per cent.

S E C T.

[a] There is a *brown-silver-ore*, called *Leber ertz* also, by the Germans, which contains *arsenic*, and *regulus of antimony*.

The colour of this ore is of a reddish brown, sometimes dark grey. It is found also crystallized into pyramids: but for the most part it is amorphous.

When scraped it appears red.

It contains from 1 to 5 per cent. of silver.

The greatest part of this ore is copper, and the next proportion is arsenic. *Kirwan*, Sp. 10.

The copper in this ore amounts to 24 in the hundred. It is found at *Dal. Berg. Sciag.* 170. in *Transylvania*, and lately at *Altheire* in *Grenada* of *Spain*. This was of a hard solid consistence, and of a greyish blue. *Mongez*.

[b] Sometimes it contains a mark, i. e. half a pound of silver per centum. It is likewise found sometimes to contain a very trifle of silver only. *Brunnich*.

There

S E C T. 275. (Additional.)

Silver, with iron, arsenic, and cobalt, mineralised by sulphur.

This ore looks like the *Weissgulden*, (Sect. 272), excepting that the cobalt, by its decomposition, gives it a rosy appearance. There are two varieties of this ore; one of a dull, tarnished surface, and of a ferrugineous look:

The other variety has a shining appearance, like the fracture of the silver-grey ore of the preceeding Sect. 274.

This ore produces some times 10 *per cent.* of silver. It is to this species of ores, that the *silver goose-dung ore* belongs. *Berg.* and *Mongez.*

It is distinguished by the rose-coloured particles of cobalt, dispersed through a *dark brown, blackish, or grey*, and sometimes *shining* solid mass.

It is found in *Saxony*, and at *Allemont* in *Dauphiné*.

There is another ore called *Leberertz*, in Germany, which contains *arsenic* besides the *sulphur*; and the antimony is in a reguline state. This ore, in point of colour, varies from a *dull white* to *grey, a k blue, brown, or black*.

It is found in a capillary form, or like wool, sometimes loose, at another time *attached*. Its filaments are rigid and inflexible. The whiter it is, the richer; but it seldom contains *one per cent.* of silver. *Kirwan*, Sp. 11.

It

It contains about 40 or 50 *per cent.* of silver, and very little cobalt. The arsenic is in an acid state, and united to the cobalt. *Kirwan, Sp. 12.*

S E C T. 276. (174.)

6. With sulphurated copper and antimony, *Argentum cupro & antimonio sulphurato mineralisatum.* The *Dal Fahl-ertz* [a].

This resembles, both in colour and texture, the dark-coloured *Weissgulden*, or *Falertz*. When rubbed, it gives a red powder.

a. Solid.

b. Crystallised, is found in the parish of *Aminskog*, in the province of *Dal*; and at that place has been for several years melted by a method invented for the

[a] There is another like the above, under the same name, which contains arsenic, besides the other component parts.

This is a hard grey, or dark grey ore, more or less brilliant; sometimes crystallized, but mostly amorphous. In fact it is the *grey-copper ore* (of which in its place) impregnated with silver, which it contains from 1 to 12 *per cent.* and from 12 to 24 of copper, the remainder being sulphur and arsenic, with a little iron. The richer it is in copper, the poorer it is in silver, and reciprocally.

Mr. Monnet remarks, that wherever copper is united to arsenic, silver is also found.

This is the commonest of all the silver ores. *Kirwan.*

Another variety of this ore has been found at *Schmitz*, which contains some gold, besides the silver. The grey-silver ore is sometimes black, and is called *Schwartz guldenertz*, by the Germans, and *Negrillo* by the Spaniards. *Mongez.*

different

different mixture of the ores ; which process must be very troublesome to those who are not perfectly well versed in metallurgy.

It contains thirteen ounces of silver, and twenty-four per cent. of copper.

S E C T. 277. (175.)

7. With fulphurated zink, *Argentum zinco sulphurato mineralisatum*. The *Pecbblende* of the Germans.

This is a zink-ore, mock-lead, or blende, which contains silver, and is found among rich silver and gold ores ; for instance, in the Hungarian and Saxon mines.

a. Of a metallic changeable colour.

1. Solid, and with fine scales.

2. In form of balls. The *Kugelertz*, or *Ball-ore*.

It is found at *Shemnitz*, and contains also gold. Its yield of silver is twenty-four ounces per cent. and thirty per cent. of zink [a].

b. Black *mock-lead*, or *blende*, found in Saxony.

This is also found,

1. Solid, and in fine scales ;

2. And in form of balls.

[a] At present they know nothing of the *globular blend*, and *globular-ore* there. In Bohemia, near *Joachimsthal*, there is a *black-blend*, which is very heavy, and whose surface is elevated, like some kinds of *hematites*, but they have not been able to get any silver out of it. *Brunn.ch.*

S E C T. 278. (176.)

8. With sulphurated lead. Potters ore. *Gzlena*. Bleyglanz, *Germ.* (See Sect. 188. of the Author.) [a].
9. With sulphurated lead and antimony, called *Striperz*. (See Sect. 190. of the Author).
10. With sulphurated iron, *argentum ferro sulphurato mineralisatum*. *Siiberhaltigerkies*, marcasite holding silver [b].

At *Kongsberg*, in Norway, it is said, a liver-coloured *marcasite* is often found, particularly at a mine called *Fraulein Chriftiana*, &c. This *marcasite* contains of silver, from three to three ounces and a half *per cent.* [c].

[a] This ore is called also *Pyritous Silver*. It is of a brown colour. It produces a very small portion of silver: and it is found at *Kungsberg* in Norway. *Mongez*, § 164. A.

[b] This ore produces *half an ounce* of silver *per cent.* There are great varieties of this ore, and many produce a considerably larger quantity of silver. *Berg. and Mongez.* § 165.

[c] The Hungarian *gils*, which contains gold and silver, will doubtless be found to contain some iron, though its constituent parts are not yet sufficiently examined.

11. With sulphurated and arsenical cobalt. *Argentum cobalto sulphurato & arsenicato mineralisatum*. Is found at *Morgenslern* near *Freyberg* and *Annaberg*. Sometimes there are *dendrites* in the stone. These kinds generally wither in the air, and lose the silver they contain. In water they keep very well. *Brunnich*.

S E C T. 279. (Additional.)

Silver mineralized by Sulphur, with Regulus of Antimony and Barytes.

The Butter-milk Ore.

This is found in the form of thin particles, on granular Spar. *Kirwan, Sp. 13.*

Perhaps is the same described by Wallerius, p. 346. of his second volume, by the words *lutosæ, obscura, pinguis*. He says, that this ore is soft like *mud*, and feels like *butter*; and suspects to be produced from other silver-ores, which are washed away by the running waters. Bomare adds, that the miners look upon it as a certain sign of being arrived in the vicinity of the rich ore; but some others are singularly persuaded, that it is a green or unripened silver-ore, which will soon become a perfect ore, &c. *The Editor.*

S E C T 280. (Additional.)

Combustible Silver-ore.

This is a black and brittle substance, and leaves about 6 *per cent.* of silver in its ashes. It is in fact a coal, in which silver is found. *Kirwan, Sp. 14.* Lehmann speaks also of silver found in coal-matrices. *Journ. de Phys.* for March 1779, p. 183.

S E C T.

S E C T. 281. (177.)

The Horn-silver-ore.

12. With the acid of common salt, *argentum acido salis solutum et mineralisatum*.
Minera argenti cornea. Hornertz, or
Horn-silver-ore [a].

This is the scarcest silver ore; it is of a white or pearl colour, changeable, or varying
 on

[a] It is sometimes found in snowy cubic crystals, of which the academy at Freyberg have a fine specimen. In 1747, were found many pieces of it at *Ober-Schöna-Brunnich*.

This scarce and valuable ore is either of a *white, grey, pearly*, or yellow, green, brown, purple, and black colour. Its principal character is its change into a *violaceous* brownish colour, when exposed to the Sun's beams, as it happens also to the artificial *horn-silver*.

It is frequently crystallized in a cubic form; sometimes it resembles an earth, easily fusible without smoke: the black sort is friable, and easily pulverised; but the other sort is in some degree malleable, may be cut with a knife, and takes a sort of polish when rubbed.

The *vitreous-ore*, which is sometimes mixed with the *black-horn-silver*, is soluble in nitrous acid: and may, by that means, be separated, the saline only being insoluble in that acid.

When the horn-silver is pure from iron, it contains *70 per cent.* of silver at least; but these ores mostly contain some portion of iron, of which some is even united to the marine acid, according to Montet.

This ore is found in *Bohemia*, *St. Marie aux Mines*, *Siberia*, *Allemont* in *Dauphiné*, *Johan Georgenstadt* in *Saxony*, *Guadal-canal* in *Spain*, and in *Peru*.

on the surface, semi-transparent, and somewhat ductile, both when crude, and when melted. It cannot be decomposed without some admixture of such substances, as attract the acid of the sea-salt. It is found in very thin worked or wrought leaves or crusts, at *Johan Georgenstadt*, in *Saxony*.

S E C T. 282. (Additional.)

Silver Goose-dung ore.

This is of a greenish colour, mixed with yellow and red. It is said to contain about 6 per cent. of silver. Some think it a mixture

It was first essayed by Mr. P. Woulfe. *Phil. Transact.* for 1776, and afterwards, though less exactly, by Mr. Monnet.

Mr. Woulfe was the first who discovered in this ore the presence of the vitriolic acid.

Professor Bergman, in his *Sciagraphia*, § 162. mentions another kind of horn-silver, mineralized by the *vitriolic* and *muratic* acids, and *sulphur*. He doubts whether this be a different species of ore, since the sulphur and the salt scarcely admit of any other than a mechanical union. But since iron is often found, though in a small quantity, in these ores, it may form a marcasitical mixture therewith. Mr. Mongez asserts, that iron is certainly contained in the *horn-silver* ore that is found in Saxony, which is the impurest of the kind. But Wallerius, in his usual way, contents himself with distinguishing, by the external appearances of colour, the three following varieties; viz. the *whitish* horn-silver, found in *Zellerfeldt*, and in *Guadalcanal*; the *yellowish-brown*, which resembles *colophony*; and the *purple-green* found at *Georgenstadt* in Saxony. *The Editor* from Kirwan, Bergman, Mongez, &c.

of

of red silver ore, and calx of Nickel. *Kirwan, Sp. 16.*

Every one may easily observe, that Wallerius, Bomare, Romé de l'Isle, and other mineralogists, have given various names to some *silver ores*, whose contents are not quite different from one another; so that it seems rather probable they have been led by a whim of nomenclature from which no useful information can be gathered by their perusal. *The Editor.*

S E C T. 283. (Additional.)

Foliateous Silver ore. *Silberartiges, Bergzunder. Blatter erz.* in German.

Its colour is *mortdoré*. Some think it to be a *native silver ore*; others take it to be a mixture of *galena*, *ochre*, and *silver*.

This ore is found sometimes in the Mountain-cork (Sect. 69), and is so light, that it may swim on water. It contains but *one ounce* of silver *per quintal*, *Kirwan, Sp. 17.*

S E C T. 284. (178.)

Observations on the Silver-ores.

Silver may, perhaps, be found mineralised in the like manner with other metals than these here enumerated, such as with cobalt

and bismuth; but having no certain knowledge of such mineralizations, I omit them here [a]. It would be worth examination, if in those mine countries where gold and silver are found in quantity, other ores do not contain a little of those metals, more especially when the particles of silver and gold have not been able to extricate themselves from the other minerals, and lie separate from them in the *fissures*, *veins*, and *shakes* or *wranks*, that is to say, in the hollow places in the mines.

Those silver-ores which are named from earth or stones, wherein the silver is found; as, for instance, in the *Goose-dung silver ore*, and the *Leberertz*; ought no more to be considered in a natural system than other distinctions which are used at mineral works, and are only names given to the ores, according to the several changes they undergo to make them fit for the melting process [b].

[a] Our author doubts whether silver is ever found mineralized with *cobalt* and *bismuth*; but the ores from *Scheerberg* and *Annaberg*, are convincing proofs of it.

Silver has also been found in an amalgama with quicksilver, in the mines of *Salberg*. *J. R. Foster*. See Note a to Sect. 267.

[b] Notwithstanding this well-founded observation of our Noble Author, many mineralogists have made long catalogues of ores, whose varieties only consist in mere accidental circumstances. *Wallerius*, in his *Spec.* 401. has made numerous articles of the different colours and earths, with which the silver ores are found; a small part of which have been seen in Note b, to Sect. 267. *The Editor*.

A mi-

A mineralisation of silver with alkali has been recently mentioned: it is said to have been found at *Annaberg* in *Austria*. But this discovery, which is made by a mine-master, Mr. Von Justi [c], requires an explanation, since the author, in his description, does not observe the necessary distinction between alkali and lime; and quotes the *horn-silver ore*, and the *luna cornea*, as proofs of his opinion; by which, however, his opinion seems rather weakened than confirmed.

S E C T. 285. (179.)

Platinum Linnæi.

Platina. White gold. Platina del Pinto, or *Juan blanco* in Spanish.

This metal is a recent discovery of our times, and is described with great accuracy by Scheffer, in the Acts of the Royal Academy of Sciences at Stockholm, for the year 1752; as also by Dr. Lewis, in the Philosophical Transactions for the year 1754, vol. xlviii [a]. And though these two gentlemen agree

[c] The silver in the alkaline lime-stone of Mr. Justi, from *Annaberg*, is native, as appears when it is polished. *Brunnich*.

[a] Mr. Macquer says, that in the year 1741, our countryman, Mr. Wood, brought to England from Jamaica, some platina, which was said to come from *Carthagena*, in the Spanish

agree in the principal circumstances relating to this metal, yet it is very plain by their descriptions; that neither of them knew any thing of the other's experiments. By these descriptions we are convinced of the resemblance this metal bears to gold; and therefore we must allow it to be called *white gold*, though, both theoretically and practically, it may be distinguished from gold by the following qualities.

1. It

Spanish West India; and that he had made some good essays of it. That in the year 1744, some vague accounts were published of this substance by Mr. Ulloa, in the printed account of his voyage with the French academicians to Peru, for measuring a degree of the earth near the Equator; and that he (Mr. Macquer) had worked with Mr. Baumé on this new metal, for which purpose he quotes the Memoirs of the Academy of Sciences for the year 1758.

Alonzo Barba, a Spanish metallurgist, quoted by Bomare, speaks of a mineral, called *Chumpi*, similar to the Spanish emery, and found among the red and blackish gold and silver mines at *Potosi* and *Choyaca*, in the Spanish West Indies, which was presumed to be the true *native platina-ore*. This emery was called *Gold* or *Silver Emery*, and is now extremely rare in Europe.

But the most satisfactory account we have of the mines of Platina, is that given in the *Journal de Physique*, for November 1783, under the signature M. L. It is at *Nevita* and *Citara*, on the North of the Province of *Choco*, in the Spanish West Indies, that platina is found, more or less mixed with particles of gold; when these are too small to be picked out by hand, they are separated by amalgamation with mercury, as commonly used in similar cases; and from this operation proceed those little globules of mercury, found sometimes with platina; but not that they be naturally found together. In fact, there is not in the whole Spanish America any other

1. It is of a white colour.
2. It is so refractory in the fire, that there is no degree of heat yet found, by which it can be brought into fusion by itself, the burning-glass excepted (see the Note p. 573). But, when mixed with other metals, and semi-metals, it melts very easily, and especially with arsenic, both in its metallic form, and in form of a calx or glass.

3. It

mines of mercury, but at *Guanacavilica*, in the Peru, at the distance of above nine hundred miles from *Choco*; and it is further confirmed, by observing, that no such globules of mercury can ever be discovered in those parcels of Platina brought to Europe, when some particles of gold are mixed with it; this last being the true state of the native Platina, such as it is found in the ground. These mines are of the secondary kind, being found in strata of loose earth, that have been washed off from higher grounds. But the primitive or original mines, where platina has been produced, have not yet been discovered in any part of the globe.

The quantity of gold particles, intermixed with platina, is sometimes so inconsiderable, that it is not worth the expences attending the amalgamation with mercury. Very often it contains, 2, 3, 4, and more ounces of *platina* in the pound of *gold*; and what is remarkable, both these metals are constantly of the same form.

Platina is always found in the form of very small particles, from the minutest sand size to that of a common pea; although this last is very seldom to be met with. The above M. L. says, that he had some native particles, or pieces of platina, which weighed from 15 to 20 grains; and adds, that on trying some of these between steel-rollers, in the presence of Messieurs Tillet and Darcet, at Paris, they were perfectly laminated, which evinces, that platina, in its native form, is malleable. The same Naturalist adds, that a native piece of platina was found nearly of a square figure, almost as big

3. It does not amalgamate with quicksilver by itself, but only by means of the acid of common salt after a long trituration. This metal seems therefore really separated from gold by amalgamation, at those places where it is found; and, without this quality, it would be very difficult to separate it.
4. It is harder and less coherent than gold.
5. It is heavier than gold; and therefore the heaviest of all bodies hitherto discovered. For though the specific gravity of platina, in the hydrostatical experiments made by Dr. Lewis, is found to be to water only as 17,000 or 1600; yet, when melted with

as a pigeon's egg, which was deposited in the Royal Society, at Biscaya, which must be the same, known by the name of *Bafcongada*, or the *Society of the Friends of their Country*. But the common size of the particles of native platina, hardly exceeds that of a millet corn; and almost every one is of an oblong form, very flat, round edged, with a smooth surface, and of a whiter colour than iron; but always intermixed with black ferruginous sand. Most of its particles are friable, and magnetic: those which remain after the separation, operated by means of the magnetic bars, still contain about one-third part of iron, according to the experiments of the Count de Sickingen.

I had the opportunity of examining a large parcel of platina (about 72 pounds troy weight) brought from Spanish America, among which I found not only a great quantity of ferruginous sand, but many bits of vegetable stalks and seeds, and also some very small red crystals, like rubies. These last I sent to Mr. Achard, the ingenious and celebrated chemist of Berlin, who tried them as far as their minuteness and small quantity could permit; and concluded they were real rubies. *The Editor.*

other

other certain metals, its specific gravity has, by an exact calculation, been found to be considerably augmented, even so much as to 22,000 [b].

6. Dissolved in *aqua regia*, and precipitated

[b] According to Mr. de Morveau, the specific gravity of platina, reduced to a metallic mass, by the process of M. de l'Isle, which is the same of Count de Milly, mentioned in the next note [d], is - - - - - 10,0353

That of native platina in grains, according to the Naturalist M. L. above-mentioned, is - - - - - 15,6817

That which is not attracted by the load-stone, according to the same M. L. is - - - - - 16,2519

And that purified by the muriatic acid, according to the same Author, is - - - - - 16,7521

But according to Morveau, *native platina* in grains, has the specific gravity of - - - - - 16,6870

According to our Author Cronstedt, it is - - - - - 17,0000

According to Bergman in his *Sciagraphia*, - - - - - 18,0000

When reduced into a metallic mass, and well hammered, according to Morveau, it is - - - - - 20,1700

Finally, Dr. Withering mentions, that by some late experiments, made by Count de Sickingen, and published in German, by Professor Succow; the specific gravity of *pure platina*, seems to be - - - - - 21,0000

One of those specimens I received from the late Count de Milly, which he rendered malleable by the process hereafter mentioned, in Note [d], being nicely examined by Mr. Nicholson, in a very good hydrostatical balance, shewed its specific gravity to be, in the temperature of 60 degrees of *Fahrenheit's thermometer* - - - - - 21,370

Another specimen of the same, which was not magnetic, being examined also by Mr. Nicholson, after it had been melted by Parker's lens, and well hardened with a hammer on the anvil, shewed in the same temperature, - - - - - 22,700

Finally, Mr. Kirwan, p. 239, of his *Mineral*, says it to be 23,000

The Editor.

with

with tin, or with a solution of that metal, it yields no *purpura mineralis* [c].

Except

[c] This metal is soluble in *aqua regia*, as is likewise gold: and in the muriatic acid, when dephlogisticated, which, in that state, dissolves every metal: and perhaps in the vitriolic acid also, when distilled upon manganese; no other acid acts upon platina, without its having undergone a previous calcination. But its precipitation, by volatil alkali, does not fulminate: neither does it produce a purple powder with tin, as our Author has observed.

The solution of Platina in *aqua regia*, is at first yellow, but when further loaded grows red, and of a proportionally deeper colour. Upon evaporation, crystals are formed of a deep red colour, frequently opaque, but sometimes pellucid, very small and irregular, resembling angular grains, which, when washed, require far more boiling water, than gypsum does, for their solution.

A small quantity of vegetable alkali precipitates a different sort of octoedral crystals, soluble in water; and a larger quantity precipitates a yellow spongy powder insoluble in water, which is the calx of platina. This may be dissolved more or less in all the known acids.

The celebrated Margraaf denied, that the solution of platina could be precipitated by the mineral alkali; and Dr. Lewis confirmed this assertion, upon his own experiments. But Bergman found that by pouring a large quantity of its solution, and still better by employing the dry and spontaneously calcined mineral alkali, the genuine calx of platina was precipitated.

Platina is precipitable from its solution in *aqua regia*, by *salt ammoniac*, as our late learned chemist Dr. Lewis discovered; this is a property by which this metal may be easily distinguished and separated from all others.

Lime also, whether aerated or caustic, precipitates likewise platina from its solution, as well as the mineral alkali.

It may be purified from iron by reiterated coction in marine acid; solution in *aqua regia*, and precipitation by the purest sal ammoniac; for platina is not precipitable by the
Prussian

Except these, this metal has the same qualities as gold; but it cannot, on account of its refractoriness in the fire, be worked off pure on the cupel, neither can it be worked with antimony; because, before it is rendered perfectly pure, it cools, grows hard, and retains always some part of the added metals [d].
It

Prussian (or *phlogisticated*) *alkali*, as all other metals are, nor by the solution of the *vitriol of iron*. By these two precipitants the mixture of any *iron* or *gold*, that may still remain in the solution of *platina* in *aqua regia*, may be first separated, before its being precipitated by the solution of salt-ammoniac, and the *platina* may then be had perfectly pure. *The Editor*, chiefly from *Bergman and Kirwan*, &c.

[d] *Platina*, when perfectly pure in its metallic state, says *Dr. Withering*, is not calcined by deflagration with nitre.

It does not admit of being hardened or softened, by tempering like steel or other metals.

It has been drawn into a wire of $\frac{1}{100}$ of a line in diameter. This wire admitted of being flattened, and had more strength than a wire of *gold* or *silver* of the same size. *Withering*.

N. B. I suspect this to be the $\frac{1}{100}$ of an inch, as no such wire as here mentioned can be made. *Editor*.

Platina is not fusible by the strongest fire, but melts in the focus of a strong burning lens.

I have seen at Paris, that the great burning lens, of which the late generous Mr. Trudaine made a present to the Royal Academy of Sciences of Paris, and whose cost amounted to about one thousand pounds sterling, only agglutinated its particles in 20 minutes. But Mr. Parker's burning lens, in London, perfectly melted them in less than two minutes. This last burning lens is of solid *flint-glass*, about 3 feet diameter; but the French was made of two glass-curved-plates, of 4 feet diameter, and filled with about 40 pints of spirits of wine. I am told that this costly instrument has been lately broken by some accident or other. *The Editor*.

From

It is brought to us only in its native state, in small, irregular, rugged grains; and it is yet uncertain

From considering the very interesting experiments of the Count de Sickingen, I apprehend the following method, to obtain pure and malleable platina, will be found a good one.

Dissolve the grains of native platina, that are least magnetic, in *aqua regia*: precipitate the iron by means of phlogisticated fixed alkali: then precipitate whatever else will fall, by caustic vegetable alkali: saturate the liquor with caustic fossil alkali, and set it by to crystallize: the yellow crystals thus obtained, are to be hammered together at a welding heat, and the metallic parts will unite. *Wiskering on the* Sciagraphia of Bergman.

Platina, however, may be reduced otherwise to a malleable state. The method which the late Count de Milly employed at Paris, and which whole operation he was so obliging as to do in my presence, and at my request, is as follows: 1st, he separated all the sand and other heterogeneous particles, by blowing them out whilst the grains of platina were letting down from one paper to another paper. He put the metal in a matraass, with 20 times its weight of *aqua regia* on a sand heat; the next morning decanted it from a sediment, composed of some whitish particles, of a metallic appearance, mixed with a blackish matter, which he told me was a molybdenic substance. He then mixed with it an equal quantity of distilled water: precipitated the platina by a solution of ammoniacal salt; and he filtrated the liquor through blotting paper; this, and the residue being dried in a plate over the fire, was put on a Hessian-crucible, which he guarded within another larger crucible. This was covered with a test, and put on a blast furnace, till it was red hot, even to a white heat, during *half an hour*; he then opened the crucible, where I saw the metallic substance, like a filamentous mass; this he pressed down with an iron rod, whose end was formed into a flat button: he covered it again, and continued the fire for ten or twelve minutes; the crucible being taken out, the solid mass was connected at the bottom: could be forged, and beaten, on the anvil with the hammer, into any form, like iron.

uncertain whether it is found naturally mineralised. The Platina is brought to Europe from

iron. I have some small specimens of this metallic mass, which do not differ in colour from silver; and I have also some that was flattened between the rollers, and is very springy: all these are attracted by the load-stone: but on my exposing a bit of this bar of platina to the focus of Mr. Parker's burning lens, it easily melted, retained its perfect malleability, and lost its attraction to the magnet: while the buttons, that had been fused of the grained platina, by the same lens, were not malleable, but very brittle under the hammer.

The chemists of Dijon say, that they have fused, very easily, platina in a strong blast furnace, by means of their new flux, by which iron, and all other hard metals, may be fused also, to the great advantage, as Mr. Tillet has tried on the calces of copper, from which he got five *per cent.* more than by the *black flux*, though helped by tallow. This new flux consists of 8 parts of *powdered glass*, one of a *calcined borax*, and half of *powdered charcoal*. But they do not say whether the platina, after being so fused, was perfectly malleable, and fit to be worked to any advantage.

Platina may be alloyed with all metals, and fused with them in various proportions; but these mixtures are not such as to offer any advantages, being either too hard, or so imperfect, as to shew a very coarse grain. That with gold seems the best of all.

It is said, that the Spanish miners in America, have the art of treating platina, with a small quantity of sulphur and arsenic, so as to melt it easily, for making various pieces of use, as *snuff-boxes*, &c.: but I never heard of such pieces being brought to, nor seen in Europe.

According to the above quoted Mr. Bomare, in his *Mineralogy*, platina is easily fused by means of sulphur or arsenic: but he does not say that he has seen the operation tried. And Mr. Macquer asserts, that this metal may be fused by the addition of *liver of sulphur*, as gold may also by the same means.

Mr. Achard, the famous chemist of Berlin, discovered an easy method of fusing platina, so that crucibles, and other utensils

from the *Rio del Pinto*, in the Spanish West-Indies. See Note [a].

utensils of this unalterable metal, may be made without great trouble, for chemical purposes. The Author communicated it in a letter he wrote to me on the 18th of February, 1784. It consists in mixing, with *platina*, an equal weight of *white arsenic* in powder, and as much of *salt of tartar*. The mixture is exposed in a crucible to the heat of a wind furnace: it soon fuses together; and being thrown on an iron plate, the metal, when cold, is very brittle; it is then pounded in a mortar; and, having prepared a proper mould of very refractory clay, it is filled with the metallic powder, and exposed to a violent fire of copellation, till the arsenic be entirely evaporated. By these means the metal remains in its metallic form, with the very figure of the mould. Mr. Crell has published this process in his *Chemical Journal*; and the same was inserted in *Journal de Physique*, for June 1786, page 456. Mr. de Morveau has given also an account of his experiments on this subject, in the *Memoirs of Dijon* for 1785, page 106, and says to have succeeded, by making, in this method, some improvements. He says, that the *arsenic* and *salt of tartar* produced an overboiling froth, which ran off from the crucible; and that the arsenical fumes were very troublesome. But my friend, Mr. Babington, has fused in my presence, and at my request, *two ounces of platina*, in a wind furnace, at the Laboratory of Guy's Hospital, observing with care the above directions of Mr. Achard; and there was not the least inconveniency of the arsenical fumes, these being immediately drawn up the chimney, whenever the test or cover was taken from the crucible, to examine the going on of the operation; nor was there observed any overboiling froth, &c. A lump of the metal was produced by the first operation, which was of a fine grain; but very brittle. Mr. William Cooper undertook also this process at my request, and the event was the same; even after he urged the fire for above two hours, to the 162 degree of *Wedgwood's thermometer*, the brittle lumps only became harder, but by no means malleable, as by the above process of Count de Milly: and the same happened to another like lump of platina exposed by Dr. Pearson, to the greatest heat of his wind-furnace. *The Editor.*

S E C T.

S E C T. 286. (216.)

Quicksilver, Mercury. *Hydrargyrum, Argentum vivum, Mercurius.* Lat.

General properties of Quicksilver.

Mercury distinguishes itself from all metals, by the following qualities [a].

a. Its colour is white and shining, a little darker than that of silver.

b. It is fluid in the cold, and divisible by the least force; but, as it only sticks to a few

[a] 1. It were almost superfluous, says Mr. Kirwan, to mention any other character of quicksilver, than its liquidity, to distinguish it from other metals. In regard to this property, Bergman observes, that Mercury constitutes one extreme among the metals, and Platina the other; since it requires to be melted, only such a degree of heat, as is rarely wanting in our atmosphere, and boils at the 600 *deg.* nearly after lead melts. See the Table at p. 509. But, when the cold is increased to the temperature, denoted by 40 degrees below *nought* both of Fahrenheit's and of the Swedish thermometer, which both coincide in that point (since $212 - 32$, or $180 : 100 :: 32 + 40$, or $72 : 40$), this metal concretes like any other metal; becomes quite solid and malleable like lead. The accurate experiments, made by Mr. Hutchins at Hudson's-Bay, on this metal, as related in the *Philos. Transactions*, for the year 1783, p. 303. have proved this fact beyond all controversy. Mercury, in its common state therefore, as the same Bergman pronounces (in his *Treatise of Ele&A. Attract.*) is to be considered as a

P p

metal

few bodies, to which it has an attraction, it is said that it does not wet.

It

metal in fusion; and since, in its solid state, it is nearly as malleable as lead, it by no means ought to be placed among the semi-metals, otherwise every other intire metal should be considered as brittle, for none is maleable when in fusion.

2. Quicksilver is as *opaque* as any other metal. Its *specific gravity* is the nearest to that of gold itself. Its *indestructibility* by fire, air, water, or other agents, and its *reducibility*, or power of recovering its metallic state, with all its former properties, by itself alone, in the fire, are as compleat as those of the *perfect metals*. Boerhaave had the patience, as Dr. Lewis says, of distilling *eighteen ounces* of mercury 511 times successively, and it was not altered in any degree; it only appeared to him a little more brilliant, heavy, and fluid, which surely depended only on a very compleat purification, as Fourcroy remarks. See note *b*, N^o 5, to Sect. 296.

3. The same Boerhaave kept mercury in a constant agitation for many months; digested it, for upwards of 15 years together, in low degrees of heat, both in *open* and close vessels, by itself, and in conjunction with other metallic substances; and received from all his labours only this result, that mercury is not, by any of those means, to be changed at all, as the same Dr. Lewis observes.

4. It is true that mercury may be calcined by heat alone. For this purpose it is put into matrasses, with long necks and flat bottoms, that the mercury be there spread with a large surface and a small depth: the necks are drawn into capillary tubes, by the flame of a lamp with a blow-pipe; and their ends are left open, or broken, to leave a communication with the external air: the matrasses are then exposed to a boiling heat in a sand-bath for night and day: in about 15 or 20 hours, some *red powder* is formed, and seen swimming on the surface of the mercury; but the process is continued for weeks and months, to increase the quantity. This is wrongly called *Precipitate per se*, it being only a real metallic calx; and as such, cannot be formed without the communication of the external air. It is *specifically* lighter, though its *absolute weight* is increased by $\frac{1}{12}$ above that of the mercury employed in the calcination; and
contains

c. It is volatile in the fire [b].

d. Its

contains the *purest air*, first discovered and named *dephlogisticated*, by Dr. Priestley. But this very calx may be reduced again, like that of *noble metals*, into perfect running quicksilver, without the addition of any other phlogistic substance, notwithstanding it is so fixed, that it may be exposed to the most violent fire without loss; and may even be vitrified, as Keir, the English translator of Macquer's Dictionary, positively asserts.

5. By a heat no greater than that of the human body, or even of boiling water, though continued for some years, only a small portion of the mercury is converted into a dark greyish or black powder, called *Æthiops per se*. Constant trituration or agitation, produce the same effect in a far shorter time. This powder is also revived by heat, without any other addition. See note [b].

It is then evident, that there cannot be the least hesitation for ranging mercury among *entire metals*, as Bergman, Cramer, Linnæus, Fourcroy, and other mineralogists have done. But the Academicians of Dijon (vol. I. p. 114.), and Mr. Kirwan (p. 227. of his Elem. of Mineralogy) classed Quicksilver among the *perfect metals*, to which opinion I very willingly subscribe. Notwithstanding the Noble Author had left it among the *semi-metals*, which I can attribute only to his modesty, for not contradicting the most general opinion of his contemporaries; although he had expressed his mind rather to the contrary at the beginning of the Note [a] to Sect. 260. p. 506.

[b] The volatility of this metal is such, that even in the temperature of the atmosphere, little globules of mercury are sometimes gathered from its emanations in the inside top of the tubes of barometers. Mercury being inclosed in a strong box of iron, and the joints well soldered together, was put on the fire of a furnace, to try whether it could be fixed according to the expectation of the alchemists: the event, however, shewed, that it was reduced into vapours of such an expansive force, that it exploded with the utmost violence, tearing the iron into pieces, and every thing it met with in its way. This happened in the laboratory of Mr. Geoffroi junior; and Mr. Beaumé was witness to the accident, as Mr. Macquer relates in his *Chymical Dictionary*. The Editor.

P p 2

The

- d.* Its weight is next to that of gold, viz. to water, as 13,593 :: 1000 [*c*].
- e.* It attracts the other semi-metals and metals, and unites with them all, except *cobalt* and *nickel*, with which it cannot by any means yet known be made to mix. This union is called an amalgamation [*d*].

This

[*c*] The *specific gravity* of Mercury is found so variously estimated by different authors, that there is scarcely any ground to judge what is the fittest to be followed. See Note [*b*] to Sect. 296. The Editor.

[*d*] 1. The Chemists of Dijon look on the amalgamations of mercury with other metals, as real solutions, which all depend on the mutual attraction between two or more substances, exerted in the *dry way*, and quite similar to those which take place in the *humid* or *moist way*; there being no other difference between both, than the form and the application of the crucible, or of the alembic, appropriated to contain the substances during the operation, according to the intensity, or mildness of heat, and to collect the results, &c.

2. The great attraction that subsists between gold and mercury, has already been mentioned in Note [*I*] to p. 519. And it is from this great affinity, that the globules of Mercury lose their sphericity, if placed upon some metals, particularly gold, on which they spread themselves, like water upon moist bodies, as the late ingenious chemist, Dr. Lewis, remarked in a note to Neumann's Chemistry, p. 133, of the 8vo edition, vol. I.

3. Mercury unites with gold, and also with silver; less easily with lead; still less so with tin; very difficultly with copper; and most difficultly of all with iron, to which it seems to have insuperable repugnance, as Neumann asserts. Dr. Lewis says, however, that quicksilver, in certain circumstances, seems, in some small degree, to act upon iron. That a plate of tough iron, kept immersed in mercury for some days, became brittle. The same Author observed also, in his said Notes, p. 101. that mercury adheres to, and coats the ends of iron pestles, used in triturating certain amalgams of it with saline liquors;

This amalgamation, or mixtion of metallic bodies, according to the readiness with which they unite or mix, is in the following progression, viz. *gold; silver, lead, tin, zink, bismuth, copper, iron*, and the *regulus of antimony*: But the three latter, however, do not very readily amalgamate. The iron requires a solution of the vitriol of iron, as a medium to promote the union.

- f.* It dissolves in spirit of nitre, out of which it is precipitated by a volatile alcali, and common salt, in form of a *white powder*; but, if a fixed alcali is used, a yellow powder or calx is obtained [*e*]. *g.* But

liquors; and I found an iron wire, about one-tenth of an inch thick, very brittle, as if penetrated by the particles of the quicksilver, after I had stirred it, with that wire, whilst boiling in the tubes of barometers, for setting loose some bubbles of air that were sticking to their inside. *The Editor.*

4. It does not easily take up bismuth, or regulus of antimony, unless they are previously mingled with other metals, or disposed to unite with it by particular managements. Bismuth, nevertheless, disposes some other metals, particularly lead, to such an intimate union with mercury, as to pass along with it through the pores of leather.

5. If mercury is impregnated with one-fourth, one eighth, or even one-twelfth of bismuth, it dissolves masses of lead in a gentle warmth, without any agitation, or triture, comminution, or melting heat. These last experiments were repeated with success by Dr. Lewis. Boyle relates many curious preparations of mercury, by which it acquires very wonderful qualities, although some have been attempted by others, but without success. See Neumann's Chemistry, *above quoted*; p. 136. Vol. I. and Note [*b*] to Sect 296.

[*e*] 1. Mercury is dissolved with great rapidity by *nitrous acid*: the liquor is of a *greenish-blue colour*, but loses it afterwards, and becomes limpid. This solution, when made with-

g. But it requires a boiling heat to dissolve it

out heat, is used as a test for the analysis of mineral waters, and has different properties from that made with the help of heat. In the first case, says Bergman, very little phlogiston is lost, and the salt easily crystallizes, being *white*, and scarcely acrid. It is not precipitated by distilled water: but, by caustic vegetable alkali, it is precipitated of a *yellowish* colour; by mild alkali, the precipitation is *white*; by mineral alkali, it is *yellow*, but it soon grows also *white*; by volatile alkali, it turns to a *greyish-black* colour; by Glauber's salt, or by pure vitriolic acid, the precipitation is *white*, *granulated*, and in a *small quantity*; nor, if this precipitant has been sparingly used, does this colour appear in less than an hour: by muriatic acid, or common salt, the precipitation is also *white*, but in a *large quantity*, and in *curdles*.

2. But if the mercurial solution be put over a sand-heat, it may be charged with a quantity of mercury, equal almost to its weight. According to the Chymists of Dijon, 10 ounces of nitrous acid may dissolve 8 of mercury. The action of the solvent becomes stronger with the heat; emits great quantity of vapours: and if not taken from the fire, will be too far evaporated. Distilled water will precipitate from this solution a *white calx*, because it is more dephlogisticated, and the solvent is over charged with it; and the water changing the density of the liquor, diminishes the adhesion of the calx, as Fourcroy remarks. This *white calx* will turn *yellow*, if boiling water be poured on it. The vegetable alkali precipitates it of a *brownish-yellow*, which, by degrees, assumes a *pale-yellow* tinge: the mild vegetable, and the mineral alkalies, produce nearly the same colour; though when this last is employed, the colour turns afterwards to *white*. The precipitation by volatil alkali is quite *white* also; that by the vitriolic acid is *yellow*; and finally, a copious *white mucilaginous matter* is the precipitate by the marine acid.

3. This solution by *nitrous acid* is very caustic; corrodes and destroys animal substances; when it falls on the skin, stains it of a deep *purple brown* colour, which appears *black*: the stains do not go off before the separation of the epidermis, which

it in oil of vitriol [f].

- b. It is not affected by the acid of common salt, unless it be previously dissolved by other

which falls away in scales, or kind of scara. It is used in surgery as a powerful escharotick, and is called *Mercurial water*.

4. The same solution, by cooling, is susceptible of forming crystals, which vary from one another according to circumstances: for the most part they are like needles; are very caustic; redden the skin; and detonate when put on burning coals, provided they be dry. They are called *Mercurial Nitre*, which fuses, when heated in a crucible; exhales reddish fumes; assumes a deep yellow colour, which afterwards turns to orange, and at last to a brilliant red: in this state is called *Red Precipitate*, or *Arcanum Corallinum*. It must be made in a matras with a gentle heat, if it is designed to be *corrosive* for Chirurgical purposes.

Mr. Bayen carried the detonation of *mercurial nitre* much farther. He discovered that 30 grains of this substance, when precipitated, either by the mild *volatil alkali*, or by *lime water*; or of *sublimate corrosive*, when precipitated by *distilled water*, and properly dried, being mixed with 4 grains of *flowers of sulphur*, detonate in an iron ladle over the fire, with as great a report as that of a fowling-piece. See *Journal de Physique* for May 1779, p. 353. The Editor from *Bergman, Fourcroy, Neumann, &c.*

[f] The *vitriolic acid*, concentrated and boiling hot, seizes on mercury, and presently reduces it, if urged by heat, to a kind of *white powder* (see note [a] to Sect. 288.), which turns yellow by the affusion of hot water, but does not dissolve in it; this is called *Turbis Mineral*; but if cold water, instead of being hot, was poured in the white mass, the powder would not change its *white* colour into *yellow*, as was said above about the nitrous solution.

2. This solution of Mercury by the vitriolic acid, is accompanied with a remarkable phenomenon; which is, that the acid contracts a strong smell of *volatile spirit of sulphur*, a notable proof that part of the phlogiston of the Mercury had united therewith. See the end of Note [a] to Sect. 289.

other acids [g], in which case only they both unite with one another, and may be sublimed together: this sublimate is a strong poison.

- i. It unites with sulphur by grinding, and then produces a black powder called *Æthiops*

3. It deserves notice, that though Mercury be more easily dissolved by *nitrous* than by *vitriolic acid*; yet, if this last acid be put into a *nitrous solution* of mercury, the metal will quit the *nitrous*, in which it was dissolved, and unite with the *vitriolic acid*.

4. If Mercury be rarefied by heat into vapours, and these meet with those of *marine acid* in the same state, a *corrosive sublimate* will be formed.

This metallic salt shoots into crystals pointed like daggers, which are the strongest of all poisons. But there are various other processes found in Chemical Authors, to make this salt with more or less trouble.

5. If *corrosive sublimate* be mixed with tin, and distilled, a very smoking liquor is produced, called by the name of its inventor, the *smoking liquor of Libavius*.

The *muriatic acid* in the *sublimate* is not saturated, and from hence proceeds its great corrosive power; for if a fresh quantity of mercury be added to it, and sublimed a *second* and *third* time, a *sweet*, or mixed *sublimate*, called *Mercurius Dulcis*, and *Aquila Alba*, is produced, which is not poisonous, and is given internally as a *purgative*, or an *emetic*, according to the dose.

This *Mercurius dulcis* may be rendered still more gentle, by being sublimed *nine times*: this being digested eight days with aromatic spirit of wine, and dried after the spirit is decanted, is called the *Panacea of Mercury*. The Editor from Macquer's *Elem. of Chemistry*.

[g] *Muriatic acid* does not act upon quicksilver, unless this last be previously deprived of as much phlogiston, as $\frac{1}{16}$ of the quantity contained in the *hundred* of silver, or of $\frac{1}{12}$ in the *hundred* of zinc. See Bergman's *Sciagraphia*, and his *Treatise De Phlogisti quantitate*. The Editor.

The

Æthiops mineralis [b], which sublimes into a red striated body, called *Factitious Cinnabar*.

- k. The sulphur is again separated from the quicksilver, by adding iron or lime, to which the sulphur attaches itself, leaving the quicksilver to be distilled over in a metallic form; but if a fixed alkali be used, some part of the quicksilver will remain dissolved in the residuum, which is a *liver of sulphur*.

[b] The Academicians of Dijon say, that the true proportion to make this æthiops, is that of *one* part of brimstone with *four* of mercury. Fourcroy directs only 1 of mercury, with 3 of flowers of sulphur, to be triturated, till the mercury is extinguished. A black powder is then produced, which is the *æthiops mineral*. The combination is better effected, when the mercury is mixed with the fused sulphur: by agitating this mixture, it becomes black, and easily takes fire: it should be then taken from the fire, and the flame should be extinguished a little after, stirring the mass till it becomes into solid clots. If this substance is exposed to a great degree of heat, it takes fire, the sulphur is consumed, and a substance remains, which is of a violet colour when pulverized. This powder being put into matrasses, till their bottom is red by the force of fire, is sublimed after some hours, and artificial cinnabar is found in the top of the vessels, crystallized into brown red needles.

Mercury divided, by means of a rapid and continual motion, as that of a mill-wheel, gradually changes itself into a very fine black powder, as already mentioned in Note [a], which is called *Æthiops per se*, on account of its colour, in order to distinguish it from this *Æthiops mineralis*, mentioned in the text. *The Editor from Fourcroy, p. 446. and 479. Engl. Edition, Vol. I.*

SECT.

S E C T. 287. (217.)

Native Mercury.

A. Quicksilver is found Native, or in a metallic state. *Mercurius Nativus*, or *Virginous* [a].

This is found in the quicksilver mines at Idria in Friuli, or the Lower Austria, in clay,
or

[a.] Mines of quicksilver are very rare in the earth. According to the calculation of Hoffman, there is *fifty* times more gold got every year out of the mines, than mercury and its ores. Dr. Lewis, in his notes to Newmann (p. 154. of Vol. I. 8vo edition), says that Cramer suspects, that Hoffman only meant 5 times instead of 50; but neither the Latin nor the English edition of this Author expresses such a thought; on the contrary, he adopts the same opinion; and only adds, that mercury is much more frequently met with than is commonly believed; but being so volatile in the fire, it often flies off in the roasting of ores, and escapes the attention of Metallurgists.

2. The most considerable mines of Mercury are; 1st, those of Idria in Friuli, and Carinthia, belonging to the Imperial hereditary dominions of Austria: 2dly, Those of Spain at *Almaden*, near *Sierra Morena*, in the province of Estremadura: 3dly, Those of the Spanish America, at *Guanacavelica*, in the kingdom of Peru: 4thly, To these I may add those of Brasil, near *Villa Rica*, between *Morro das Lages* and that of *Saint Anna*, where I am told by a native of that country, that such a quantity of cinnabar and of native running quicksilver is found near the surface of the earth, that the black slaves often collect it in good quantities, which they sell for a trifling price to the

or in a black flaty lapis ollaris, out of which it runs, either spontaneously, or by being warmed even in the hands.

It

the apothecaries: but these mines never have been worked out, nor any notice taken of them by the owners. The same Brazilian told me besides, that gold naturally amalgamated with mercury, was also found in the neighbourhood of that place; and, what is more extraordinary, he asserted, that almost all the gold mines of that country, are only worked out by simply washing them with running water, after reducing into powder the hard ores, which are sometimes imbedded in quartzous and rocky matrices.

3. Neumann says, that the mines of Idrja have produced at the rate of 231,778 pounds weight of mercury *per annum*; but those of Almaden in Spain produce much more. The chemists of Dijon say, that their annual produce is about 5 or 6 *thousand* quintals, or between 5 or 600,000 pounds weight. Only in the year 1717, there were more than *two millions* and 500 *thousand* pounds weight, sent from them to Mexico, for the amalgamation of the gold and silver ores of that country.

4. Bomare asserts, that the annual produce of the mines at *Guanacavilica*, amounts to one *million pounds*, which are carried by land to Lima, thence to *Arica*, and finally to *Potosi*, for the same purpose. The Imperial quicksilver, above-mentioned, is brought to Holland, and from thence to various other parts, the Dutch having entered into a contract with the Imperial government to be the purchasers of the whole.

4. Besides the *three* great mines of quicksilver, already mentioned in this Note and in the text, this metal is found likewise in various other parts of Europe; as those at Muschel-Landsberg, in the Dutchy of *Deux Ponts*, and in the *Lower Austria*. It flows there from a *shistose*, or *quartzose matrix*; and is probably mixt with some other metal, since its globules are not perfectly spherial, as Mr. Kirwan remarks. The mines of Friul are all in similar beds or strata. It is found likewise visibly diffused through masses of clay, or very heavy stone,

It has several times been found at Herr Sten's Bottn, in the mines of Salberg, in Westmanland,

stone, of a *white, red, or blue colour*: of this kind are the mines of *Spain*, some of *Idria*, and of *Sicily*.

Mascagni, already quoted in the Note to p. 266, found *fluid quicksilver*, as well as *red cinnabar*, and also *mineral æthiops*, near the lake of *Travale*, in the Dutchy of *Sienna*: the quantity however seems to be so small, as not to deserve working. On the contrary, the following mines produce clear profits enough to be worth the attention of the owners: *viz.* those at *Kremnitz* in Hungary; at *Horowitz* in Bohemia; at *Zorge* in Saxony; at *Wolffheim*, *Stabberg*, and *Moisfeld*, in the Palatinate. Mercury is brought also from Japan in the East Indies; but the greatest part sold in Europe, as *Japan cinnabar*, is manufactured in Holland, as Neumann asserts.

5. *Native or virgin mercury* was formerly sought for by Alchemists with great anxiety and expence from *Idria*, for their great object of making artificial gold. Many others, nearly as mad, have been particularly fond of the Hungarian cinnabar, supposing it to be impregnated with gold: and so far has this ridiculous conceit prevailed, as Neumann says, that not only the mineral *cinnabar*, *antimony*, and *copper*, but the very *vine trees* of Hungary, have been imagined to participate of that precious metal. Even within these ten years, a singular French chymist announced to the public, that he had found a considerable quantity of gold in the ashes of all *vine-twigs* and *stems*, and in the residuum of *garden soil*, after incineration. I was then at Bruxelles, and my good-natured friend, the late Mr. Needham, then at the head of the New Academy of Sciences, in that capital of Brabant, was highly displeased at my want of faith on so advantageous a discovery. But I was told afterwards, that the Count de Lauragais demonstrated the fallacy and non-existence of the fact, to the full satisfaction of the Royal Academy of Sciences at Paris.

5. Another alchymical whim, was that of fixing, or reducing mercury into a solid state, so as to be employed like silver. But all processes and operations of this kind, says Neumann,

land, and sometimes also amalgamated with native silver. *See the next Section.*

SECT.

if they have mercury in them, are no other than hard amalgams. When melted lead or tin are just becoming consistent after fusion, if a stick is thrust into the metal, and the hole filled with quicksilver: as soon as the whole is cold, the mercury is found solid. According to Macquer, mercury exposed to the fumes of lead becomes equally solid. And Maurice Hoffman, quoted by Neumann, gives a process for reducing mercury, so coagulated, to a state of malleability, by repeatedly melting and quenching it in linseed-oil; so that a metal is thus obtained, which may be formed into *rings*, and other *utensils*; but the case is, that the mercury is really dissipated by the repeated fusions, and nothing else is left, but the original lead or tin of this kind of amalgam: still more ridiculous are those, who, melting an amalgam of copper and mercury, with tutty, imagine the brass that results, to be a production of the mercury; since this is dissipated by the fire, whilst the tutty, which is a kind of *cadmia fornacum*, and contains zinc, gives the yellow colour to the copper, as every one knows.

6. Wallerius, after mentioning the strong soap leys, or caustic lexivium, and other methods for fixing mercury a solid state, tells us very gravely, that, by means of a certain *gradatory water*, whose composition he affirms to have learned, with great labour, from the Treatise of Creuling *de Aureo Vellere*, he could make a coagulum of mercury whenever he pleased, of such consistency, that great part of it would sustain cupellation; but this pretended Adept has taken care not to disclose to the reader, the process to make that kind of miraculous water.

7. Lemery, Pomet, and others, lay down some external marks for distinguishing those places, in which there are mines of quicksilver; namely, thick vapours like clouds, arising in the months of April and May, the plants being much larger and greener than in other places, the trees seldom bearing flowers or fruit, and more slowly putting forth their leaves, &c. But these

e, N° 2, to the last Section, Note f, to p. 524, N° 3. to p. 526; and also by the following Sect. 292. that there naturally exist various ores of quicksilver, amalgamated with *silver*, *gold*, and other minerals, although they be but seldom met with.

It is very probable, that the extraordinary great specific gravity which is found in some specimens of running quicksilver, proceeds often from its being naturally amalgamated with gold. According to Boerhaave, it may proceed also from its being redistilled a great number of times. By the same reasoning we may suspect, that the smallest of the specific gravities of quicksilver proceed from its amalgamation with *silver*, *lead*, and other metals, and *semi-metals*, which, in spite of repeated distillations, may still preserve their union with it; and Boerhaave asserts, that after redistilling a great number of times the same amalgam of *quicksilver* with lead or tin, he never could perfectly free them, by this method, from one another. See the last Article of his Second Dissertation on Mercury, p. 139.

That Mercury is many times found amalgamated with lead, is easily evinced, by the process of Mr. Grosse, related in the Memoirs of the French Academy, and mentioned by Mr. Macquer in his *Elements of Chemistry*, p. 296. Chap. 6. in 12mo. of the fifth English edit. where the method of extracting mercury from some solutions of lead is described; but the same Macquer, in his *Chemical Dictionary*, p. 205. Vol. III. in 12mo. positively affirms, that though Beccher and Kunchel have given other processes for this extraction of mercury from lead: and although the method, indicated by Mr. Grosse, be easier than the other process; nevertheless it does not succeed, if the lead is quite pure, without any amalgamation with mercury. And Boerhaave has expressly made the same assertion, complaining of those Authors who affirm the contrary. See his Dissertation de *Mercurio*, p. 133. at the end of the second vol. of his Chemistry, of the Lat. edition 1732. The Editor.

SECT.

S E C T, 289. (218.)

B. Mineralised, *Mercurius mineralisatus*.

- 1, With sulphur, *Mercurius sulphure mineralisatus*. Pure cinnabar, *Cinnabaris nativa* [a].

This

[a] Native cinnabar is of different shades, from yellowish to a deep red; and is found alone in hard, or in friable masses, either shapeless, or crystallized in cubes, and sometimes transparent. It is found also in very heavy red, or brownish red stones and sands; and intermixed with clay or stone, or interspersed through the ores of other metals, particularly those of silver, copper, or martial pyrites.

Its texture is either radiated, striated, scaly, or granular.

One hundred parts of cinnabar contain about 80 of mercury and 20 of sulphur; but artificial cinnabar contains a little more sulphur; and hence its colour is darker. Kirwan.

I have lately revived some quicksilver from native cinnabar, by mixing with it, after it was reduced into powder, an equal weight of iron filings, in a glass retort, and the loss amounted to nearly twenty-one per centum, whilst the artificial cinnabar revived in the same manner, lost 23,2 pounds in the hundred. The Editor.

It sublimes in close vessels; but is decomposed in open ones, and volatilized when sufficient heat is applied.

It is insoluble in nitrous acid, as Monet asserts, p. 313. of his Treatise on *Metallic Solutions*, edit. 1775.

Macquer says absolutely, that cinnabar is not attacked in the humid way, by any of the chemical solvents: the vitriolic acid, however, when urged by heat, may be said to calcine it, as will be mentioned hereafter.

Mineralogists reckon six varieties of cinnabar naturally found in the earth: 1. *Friable*, commonly called *flowers of cinnabar*,

Q q

This is of a red colour; and its specific gravity to water is as 7500 to 1000.

a. Loose or friable cinnabar, *Cinnabaris friabilis*, it looks like red ochre.

It is found in the Duchy of *Zweybruck* or *Deuxponts*, in Germany.

b. Indurated, *Minera Mercurii indurata*; solid cinnabar. Is of a deep red colour, and, with respect to its texture, is either,

1. Steel-grained, from *Siebenburgen*;
2. Radiated;
3. Composed of small cubes, or scaly, from *Idria* and Hungary; or
4. Crystallised,

a. In

cinnabar, or *native vermillion*. It has the consistence of a very fine powder, and sometimes has a needle form appearance. It is found in *Idria*, in the Duchy of *Deux Ponts*, at *Menidot* in *Normandy*: 2. *Striated*, in the form of *needles*, which are sometimes disposed into radiations from a common center. It is very brittle, and contains the greatest quantity of quicksilver. It is found at *Almaden*, in the Duchy of *Deux Ponts*, and in *Transylvania*: 3. *Lamellated*, or in the form of leaves: it only differs by its figure from the preceding, and is found with it: 4. *Granulated*, of a dark red colour, often of a compact and solid texture: sometimes its colour is pale, like the peach-tree flowers. It is found at *Siebanburgen*, and at the above-named places: 5. the *Argillaceous* cinnabar, so called, on account of its mixture with clay, and fat earths; its form is lamellated, and is easily dissolved in water, on account of the earthy mixtures. It is found at *Idria* and *Wolstein*: 6. finally, the *Crystallized*, which is often transparent. *Mongez.*

Professor Brunnich, in particular, says also, in a Note to this Section, that some transparent pieces of cinnabar are found also in the mine near *New-Mærketel*, in *Carinthia*.

Theo

6. In a cubical form; it is transparent, and deep red like a ruby, from Muschlanßberg in Zweybruck.

The finer coloured cinnabrine ores are never worked for extracting the mercury, but employed as pigments; but they have been very injudiciously preferred to the more pure factitious cinnabar for medical uses; as we seldom meet with any native cinnabar, that has not some mixture of earthy or stony matter, nor with two pieces that perfectly agree. In the shops three principal sorts are distinguished; viz. 1. in *masses* weighing from 1 to 6 and more ounces: 2. in *grains* prepared, by breaking the worse masses, and picking out the best coloured bits: and 3. *washed cinnabar*; which is prepared by washing of the lighter impurities that are found in it.

No native cinnabar should ever be employed internally as medicine, without being purified by sublimation. I have never met with any native cinnabar, says Newmann, that did not leave on sublimation a grey ash or sand, amounting, in different parcels, from one-ninth to one-fifth, of the mineral employed: the residuum had no gold in it, although the colour of its solution and precipitate gave at the first sight some expectation.

It is observable, says Newman, p. 157, of his first vol. in 8vo. that though vitriolic acid forms with mercury a lively yellow concrete, called *Turpeth Mineral*, and with the inflammable principle (the phlogistic substance) a yellow sulphur: and although sulphur itself forms with mercury a beautiful red cinnabar; yet the same vitriolic acid totally destroys this red colour, rendering it as white as milk. I repeated this curious process just before I wrote this Note, and found that the vitriolic acid does not produce immediately the least change of colour in common cinnabar; but being digested in a glass cup, over a strong sand heat, it soon turned as white as cream: and the vitriolic acid took the form of a strong sulphureous and volatil vapour, very suffocating and corrosive; emitting very piercing fumes for some time, which turned black the paper it was covered with, and destroyed its texture. *The Editor.*

S E C T. 290. (Additional.)

Impure Cinnabars.

The three following mercurial ores deserve to be treated of in a separate place from the pure cinnabar of the preceding section.

1. A mercurial ore is found in Idria, says Gellert (p. 57. of Ed. 1776.), where the mercury lies in an earth or stone, as if it were in a dead form; and has the appearance of a red-brown iron-stone; but it is much heavier than that. It contains from 3 quarters to 7 eighths of the purest mercury; leaves, after distillation, a very black strong earth behind, and gives some marks of cinnabar. This mineral, however, seems not, with that particular property as already mentioned, to be called an ore; but may rather be placed to the *native mercury*. For as we do not know the ultimate divisibility of mercury, we cannot justly determine the point of its fluidity, although its globules may no more be discernible.

These are the words of this great Metallurgist; and had he not said, that this ore required a distillation to disengage the metal, it might have been ranged among the native quicksilver ores. Such as it is, it deserves to be noticed in this place. *The Editor.*

2. Liver

2. Liver ore, which is most common in Idria, and has its name from its colour. To all outward appearance it resembles an indurated iron-clay; but its weight discovers that its contents are metallic. It yields sometimes eighty pounds of quicksilver per hundred weight.
3. Burning ore. *Brand-erz* in German. This ore may be lighted at the candle; and yields from nine to fifty pounds of quicksilver per hundred weight. *Brunnich in his additions to our Author's Mineralogy.*

S E C T. 291. (Additional.)

*Quicksilver mineralized with iron by sulphur.
Pyritous Cinnabar.*

Sir Torbern Bergman inserted this ore in the Sect. 177. of his *Sciagraphia*, and seems doubtful whether this be a distinct species from the cinnabar; as the iron is perhaps, says he, only mechanically diffused therein. Mr. Monges remarks, that there are but a few instances of cinnabar in which iron is not found in its calcined form; though, in the act of the ore being reduced, it passes to its metallic state, and becomes capable of being acted on by the load-stone. But if there are pyritous cinnabritic ores, as there is not the least doubt of their

Q 9 3 existence,

existence; they deserve to be ranged, in a separate section, by themselves.

Another pyritous ore of cinnabar was found at *Menidot*, near *St. Lo* in *Lower Normandy*. It consisted in grains of different sizes, of a red brown colour: they had a vitriolic taste, and a sulphureous smell.

Pyritous ores of this kind are found also at *Almaden* in *Spain*, and at *Stablberg* in the *Palatinate*. The cinnabric pyrites of this last place are of a dodecaedral form. *The Editor from Bomare's Mineralogie, vol. 2. p. 166.*

S E C T. 292. (Additional.)

Quicksilver mineralized with silver by the aerial acid, and sulphur.

This seems to be a native precipitate *per se* or calx of mercury. It is said to have been lately found in *Idria*, in hard compact masses of a brownish-red colour, &c. Mr. Kirwan extracted a part only of this article from the *Journal de Physique* for January 1784, p. 61. I will, however, transcribe a fuller account of this article, as it seems to afford some further information.

This ore looks as a calciform mass, of a solid and hard texture. It is of a brown-red colour on the outside, but of a red colour in its fracture, which is granulated.

Various

Various little globules of mercury were contained in its pores, which are rendered visible by being heated, but are soon re-absorbed by cooling.

Exposed in an iron-spoon to the fire, the red colour became more vivid; but by cooling, it turned yellowish.

Distilled in a pneumatic apparatus, a quantity of *dephlogisticated* air was produced, though less by a fourth part than an equal bulk of common cinnabar should produce; and about *ninty-one parts per centum* of running *quicksilver* were revived.

One ounce of this ore being distilled in a glass retort, a little *yellow powder* was left, which weighed $\frac{1}{4}$ of a *grain*, and stained the bottom of the retort, as the calx of silver generally does on white glass in similar circumstances. This powder being suspected to be a *calcined silver*, was cuppelled, with 144 grains of *lead*, after being wrapped up in a paper, in order to offer the phlogiston of the burned paper to the later. After incandescence, the increased weight of the lead, over that of the test of comparison, proved that the calx was reduced into its metallic state of silver, and mixed with the lead.

If this account can be relied upon, it will prove, that quicksilver, even in a calciform state, is naturally found mineralized with silver, by means of sulphur. *The Editor.*

S E C T. 293. (Additional)

Pyritous Mercurial Ores, with Silver and other Metals.

Mr. Monet, in his Sp. 77. relates, that he found in a metallic ore brought from *Dauphiné*, in 1768, by Mr. de Montigny, the following contents. This ore is of a *grey*, or *whitish* colour, and *friable*. On being analyzed, one hundred weight of this ore afforded $\frac{1}{10}$ part of *mercury* and 4 or 5 ounces of *silver*.

The remainder was *iron*, *cobalt*, *arsenic*, and *sulphur*. See his *Mineralogy*, p. 392, quoted by Mr. Kirwan at p. 312, and by Mr. Mongez, §. 178. B.

Cinnabar, mixed with *arsenic*, or *realgar*, is said to be found in *Japan*, according to Linn. Von Gmelin, quoted by Kirwan, *ibidem*, p. 312.

At Morsfeld *cinnabar*, and the white calx of *arsenic*, present themselves in the same rock. Kirwan, *ibidem*.

S E C T, 294. (219.)

Quicksilver mineralized, with sulphur and copper.

Mercurius cupro sulphurato mineralifatus.

This ore is blackish grey of a glassy texture, and brittle; crackles and splits excessively in the fire; and when the quicksilver and sulphur are evaporated, the copper is discovered by its common opaque red colour in the glass of borax, which, when farther forced in the fire, or diluted, becomes green and transparent. It is found at Muschlansberg in Zweybruck, or the Dutchy of *Deux Ponts* [a].

[a] It is said, that there is also found in the sulphur in Idria, a black cinnabar, that retains the colour in the sublimation, which seems to indicate an abundant phlogiston in the sulphur; but this requires, however, a further confirmation. *The Author.*

Dr. J. R. Forster says, too boldly on this matter, that the Author must have been misinformed, as *no such cinnabar* has ever been found; and adds, that a certain learned man thought he had likewise discovered some, near the copper ores at Lauterberg; but that it proved to be a red copper calx, which is still found there sometimes. *The Editor.*

S E C T,

S E C T. 295. (Additional.)

Quicksilver, mineralized by the marine and vitriolic acids.

Mineralogy owes the discovery of this ore to Mr. Woulfe, who published the account of it in the Phil. Transf. of London, for the year 1776. p. 618, and following.

It was found in the Dutchy of Deux Ponts, at the mine distinguished by the name of *Obermoschal*.

It had a *spar-like* appearance. This ore is either *Bright* and *white*, or *yellow* or *black*.

It was mixed with cinnabar in a stony matrix: and being well mixed with $\frac{1}{2}$ of its weight of vegetable alkali, afforded cubic and octagonal crystals, that is, *salt* of Sylvius, and *vitriolated tartar*.

The marine salt of this mercury is in the state of sublimate corrosive. The Editor from Kirwan, p. 309.

S E C T.

S E C T. 296. (220.)

Observations on Quicksilver (a).

The divisibility of quicksilver in the cold might occasion some doubt, whether it really deserves

[a] 1. The Noble Author speaks in the beginning of this Section, about the great *divisibility* (or rather *fluidity*) of Mercury in the common temperature of our climates; because it was not known in his time, that this metal becomes *solid* and *malleable*, when exposed to the cold, indicated by the 40 degrees below *nought* in the scales of the two thermometers of *Fahrenheit*, and of *Celsius*, as has been already mentioned in Note [a] to Sect. 286. It has also been shewn, in the same Note, why Mercury, far from being reckoned as one of the *semi-metals*, deserves rather to be ranked among the *perfect metals*, on account of its essential properties, which were either unknown formerly, or not attended to.

2. But this metal possesses moreover some other singular qualities, and is applied to various useful purposes, as well philosophical as æconomical, part of which requires at least to be mentioned in this and in the next Note.

3. A notable property of quicksilver is, that of its being almost regularly *expanded* or *contracted*, in its bulk, according to the greater or less quantity of heat to which it is exposed, as Mr. De Luc and other philosophers have satisfactorily proved. It is on this account, as well as on that of its possessing a permanent form in all the common variations of the atmosphere, that mercury is the fittest of all known substances in nature, to indicate with nicety the degrees of *heat* and *cold*, at any time or place whatever, independently of any reference to our sensations, which are continually varying.

4. The relative quantity of this increase or variation of mercury in its bulk, has been ascertained by Sir G. Shuckburg, in the Phil. Trans. for 1777, p. 566. to be $\frac{1}{813,77}$ ($=\frac{1}{813,77}$; though, by error of the press, it is there marked $\frac{1}{817}$), from
the

deserves to be called a metal, if it had not a right

the *freezing point* of ice (or from its *melting*, which is a more precise *point*) to that in which *water boils*. To this quantity, however, must be added $\frac{1}{800}$, on account of the expansion of the tube in which the experiments were made; so that the whole increase of the bulk of mercury, by the variation of these two temperatures, amounts to $= \frac{1}{54479} \left(\frac{63,07 \times 460}{63,07 \times 400} = \frac{463,07}{25228} \right)$ of its former bulk.

5. This quantity, however, being too small to be easily perceived, rendered it necessary to make use of a proper contrivance to form that very useful instrument, called the *Thermometer*. This consists in a hollow ball of glass, blown at the end of a narrow tube of the same substance, whose bore must be very small and very even in its whole length. This being well filled with pure mercury, boiled, and hermetically sealed, without leaving any air in the inside, is exposed to the heat of boiling water, when the barometer stands at 30 inches, the mean of its variations in our climates. The point answering to the upper surface of the inclosed mercury, is marked with a silk thread round the tube, and afterwards marked therein with a file; a similar mark being taken also when the instrument is immersed in thawing ice. The interval between these two marks is transposed upon a brass scale annexed to the tube.

6. This space, or interval, is divided into 180 equal parts, or *degrees*, according to the scale of Fahrenheit; or into 100 *degrees*, according to that of Celsius, used in Sweden: or into 80 *degrees*, according to that of Reaumur, used by the French. In the first Scale the number 212 is put on the mark of *boiling water*; 32 on the *freezing point*; and the 0° on the 32 division below it. This is the most convenient of the three thermometrical scales, since all variations of heat, in common observations, are distinctly and simply announced; and are small enough to render the use of fractions unnecessary; but those of *Reaumur* and *Celsius*, each of the first being equal to 2,25° of *Fahrenheit*, and each of *Celsius* to 1,8 of the same, require often to be subdivided, and to be distinguished by the words *above* or *below naught*, to be understood without mistake. Thus, for instance, 25 *degrees* of the Swedish thermo-

right to it from the earliest times, being then reckoned

meter, *above* or *below* $= 25 \times 1,8 \pm 32 = 77$; or to 13 degrees of *Fahrenheit's* scale; and the same number of *degrees* of *Reaumur's* scale, are $25 \times 2, 25 \pm 34 = 88\frac{1}{2}$; or to $24\frac{1}{2}$ of the same scale of *Fahrenheit*.

7. It was affirmed, in the beginning of this Note, that the expansions of the bulk of quicksilver by heat, are nearly (for they are *not strictly so*) in a regular arithmetical progression, according to the quantity of heat it is exposed to; and such seems to be the case, according to the Table published by the same Mr. de Luc, at p. 309, of his first volume on the *Moderations of the Atmosphere*. The following extract of this table shews these variations; and the first and second differences are added, in order to render these irregularities more sensible. They are such as can hardly be conceived from the nature of any substance, without the influence of extraneous and accidental causes, which may have escaped the attention of the observer; neither have they been found exactly true by Dr. Crawford. Mr. de Luc supposes the whole heat from the melting ice to that of boiling water, to be divided into 80 parts, by the fractional subdivisions of which he expresses the absolute quantities of heat, answering to each 5 or 10 degrees of Reaumur's thermometer ($= 22,5$ of Fahrenheit's scale); so that the whole sum of these fractions amounts exactly to the assumed number 80; they are as follows:

Reaumur's Thermometer.	Fahrenheit's Thermometer.	Quantities of heat.	First differences.	Second differences.
Degr. 80 212				
70 189,5		9,44		
60 167		9,60	,16	+
50 144,5		9,70	,10	,06
40 122		9,86	,16	-,06
30 99,5		10,08	,22	+,10
20 77		10,20	,12	-,06
10 54,5		10,38	,18	-,18
0 32		10,74	,36	

8. Our Author observes (Sect. 286. [b] p. 578) that, although mercury is fluid, it is by no means *wet*; unless some water be intermixed in its substance. This last is a fact I have chanced

reckoned among the metals, when even they were

chanced to see more than once, by the watery vapour that arose from boiling quicksilver, previously to fill therewith some barometers. But chemists, less accurate in their words, express sometimes the adhesion of this metal to silver and gold, saying, that it *wets them*, on account of the external appearance arising from the strong attraction it has to both.

9. Though mercury does not act on earths; it unites and amalgamates with the greatest part of metals. This is a kind of solution which makes no effervescence, because no fixed air arises from these processes; and if any loss of phlogiston happens in the conflict, it is neither very considerable, nor with such a rapidity, as to render it self-known to our senses, as the Chemists of Dijon remark, Vol. III. p. 425.

10. The following articles relating to these amalgamations of mercury with other metals, are extracted from the same third volume of the Chemistry of Dijon, where the experiments of Mr. Sage of Paris are frequently quoted; and there is not the least doubt, but they have been repeated and well ascertained by the same Academicians.

11. The amalgam of gold and mercury, crystallises into quadrangular pyramids. Six ounces of mercury are retained by one of gold in this crystallization; but that with silver contains one-fourth more of quicksilver.

12. The strong mutual attraction between mercury and gold or silver, is the ground of the method of separating these metals, when they are native, from the earthy substances, that are naturally found mixed with in the mines; the smallest metallic particles forming an amalgam with it. Part of the mercury is strained off, and the remainder is afterwards dissipated by the heat of proper furnaces built for that purpose.

13. This amalgam serves also to cover pieces of copper and silver, with a golden surface, so that they appear as if intirely made of solid gold.

The pieces being well cleaned, are dipped in a feeble *aqua fortis*; afterwards in a nitrous solution of quicksilver, which covers their surface with a kind of silvering; and finally, the amalgam of gold is very equally spread over them: this being done,

done, the piece is exposed to a proper heat to volatilize the mercury, which leaves the gold strongly adhering to the metal, &c.

14. The amalgam with silver is also susceptible of crystallization. It assumes a dendritical form: and every ounce of silver retains 8 of mercury. It is with this amalgam that is produced, by means of *nitrous acid*, well freed from the vitriolic by the *nitrous solution of silver*, that curious apparent vegetation, called *Arbor Dianæ*, or *Arbor Philosophorum*. The following is the shortest process.

Dissolve 4 *gross* ($= 228 \text{ grains} = 4 \times 72$) of silver, and 2 ($= 2 \times 72 \text{ gr.}$) of quicksilver in *pure nitrous acid*; add to the solution, when made, 5 *ounces* ($= 5 \times 576 \text{ gr.}$) of distilled water: put this solution into a spherical vessel of white glass, at the bottom of which must already be put 6 *gross* ($6 \times 72 \text{ gr.}$) of an amalgam of silver, of the consistence of butter: let the vessel be kept in a quiet place, free from any shaking or external agitation; and, at the end of some few hours, the figure of a bush, or tree of silver, will be formed within the water of the glass vessel. The metals contained in the solution, and in the amalgam, attract each other; and a number of small tetrahedral crystals are formed, which lay hold at one another's end, and form the appearance of a vegetation, as I have seen in various cabinets of Natural Curiosities.

15. Quicksilver is also employed in Chili and Peru, to extract the native silver from its ores, by amalgamation, as has just been related, of those of gold: the mercury is either separated by distillation in large retorts of iron; or else the most fluid part is pressed out, and the remainder is driven off by a distillation *per descensum*, putting it in a kind of metallic sieve over a vessel of water, to receive the mercury, which is driven down by the fire lighted in a vessel above the amalgam.

16. Copper amalgamates very difficultly with mercury, and only by mixing *blue vitriol* with mercury and water in an iron retort, over the fire. The acid attacks then the vessel, and the copper is precipitated in a metallic state, which, by stirring it hot with an iron spatula, unites to the mercury; but it shews no kind of crystallization.

17. Two ounces of melted lead being poured on a pound of mercury, produce a half fluid amalgam, which being decanted, gives some crystals like those of silver. One ounce of these crystals retain one and a half of mercury. This amalgam

is advantageously employed to lute the glass vessels, in which specimens of Natural History are to be preserved in spirits of wine, as it has an admirable effect in preventing evaporation by the close stoppage it makes.

18. The amalgam of quicksilver with tin, is advantageously employed in making looking-glasses, or mirrors. The thin sheet of tin is laid down on a large flat table of stone; a proper quantity of mercury (in which some tin has been dissolved, to avoid its destroying the tin sheet) is rubbed over, with a lump of cloth like a flat bung, and the glass is carefully slid upon it from one end to the other, in such a manner, that the dirty crust of the quicksilver is driven off before it's edge: the glass is then loaded with weights all over; by inclining gradually the stone-table, the superfluous mercury is discharged; and in a few hours both cohere together.

19. The amalgam of tin is susceptible of crystallization, which is in the form of thin shining *lamellæ*, with polygonous cavities between one another. Two ounces of tin retain 6 of mercury in this crystallization.

Quicksilver produces no amalgam with iron (See Note [d], N° 3. to p. 580.), nor with *regulus of antimony*. The first is the best intermedium to revive mercury from cinnabar: and antimony is also employed sometimes for the same operation, though not with equal advantage. See the Note to p. 593.

20. The amalgam with bismuth may be performed by heat: it produces regular crystals of an octaedral form, and lamellated triangles and hexagons; they are black on the upper surface, and shining underneath; two ounces of bismuth retain double their weight of mercury in this crystallization.

21. When fused zinc is poured on mercury, a crackling noise is heard, that resembles what is produced by a hot body when thrown into boiling water. This amalgam crystallises very well into lamellated hexagonal figures, leaving cavities among themselves. One ounce of zinc retains two and a half of mercury in this crystallization.

22. Quicksilver does not amalgamate with *arsenic*, but by the force of heat, and this in a very small quantity; nor does it amalgamate with *cobalt* nor with *nickle*.

Mr. Machy observed, that on the act of amalgamation, some cold is produced. He covered the ball of a thermometer with tin-foil, and putting it on mercury, the thermometer fell some degrees. This phenomenon thoroughly agrees with the
new

new doctrine of Dr. Crawford on *Elementary Fire*; as a solid body requires a greater addition of heat to pass from the solid to the fluid state, so that the sensible heat of the thermometer must be diminished, to unite to the tin-foil, with which it was covered, in the moment of becoming fluid.

23. This metal always feels cold, when touched, in the common temperature of the atmosphere. Fourcroy says, that we are deceived in this case by our own sensations; for the thermometer being dipped in the same mercury, does not show any lower degree of cold. The great continuity of contact between the live skin and the numerous metallic particles, in an equal space, which are proportional to its great specific gravity, necessarily produces a stronger sensation of its own temperature, this being always much less than that of a living body; and of course the multiplicity of these points of contact being all applied at once to this organ of our sensation, must be more powerfully felt, than whenever we touch any other matter that is lighter in itself, or of a much less density.

24. On the contrary, it is generally observed, that quick-silver, when exposed to the same degree of *heat*, and in the same circumstances, with various other bodies, becomes sooner hot than any of them. The fundamental principle of this phenomenon consists in the *small quantity of specific fire*, or in the *less capacity*, with which mercury is naturally endowed for receiving *heat*. This is such, that, compared with the capacity of water for the same purpose, it is in the ratio of 0,033 to 100, as appears by the Table I have published of the *specific fire* of various bodies, in my *Essay on Elementary Fire*. This Table was grounded upon various important experiments and observations made by Mr. Kirwan, in consequence of the *New Theory on Fire*, discovered and published by Dr. Crawford. Hence it follows, that if equal quantities of *heat* be communicated to two equal quantities of *water* and *mercury*, this last will have a temperature *thirty times* greater than water; that is to say, in the inverse ratio of their respective capacities, or as 1 to 30 ($= 0,033 : 1,000$): in the same manner as it must happen, when equal measures of corn, or of any fluid, are thrown into vessels, whose bottoms are as 30 to 1; for then the heights must necessarily be in their inverse ratio, *viz.* of 1 to 30, &c.

R r

25. Mercury,

25. Mercury, when rubbed between the fingers, emits a slight particular odour, as Mr. Fourcroy asserts. I have attempted this experiment many times, but without success: perhaps on account of my imperfection, in the organ of this sensation.

The same Author asserts, that when mercury is pure, if agitated, it is observed to shine with a very sensible phosphoric light, particularly in hot seasons. This phenomenon has certainly been observed in the mercury of the barometer, by several philosophers; but I do not know whether it is generally so in other circumstances: even in the barometer it does not take place, unless the Torricellian vacuum be not perfectly made in the space at the top of the tube. Phials of glass are made on this principle, containing some quicksilver, and hermetically sealed, which, on being shaken in the dark, produce light enough to see the hour on the dial of a watch. This luminous appearance is properly of the electric kind, and proceeds from the rubbing of the mercury against the sides of the glass, in a very rarified medium. But if a *perfect vacuum* be produced, by nicely boiling the quicksilver within the glass, there will not be any electric illumination. This coincides with that curious phenomenon, discovered by Mr. Walsli, and repeated by Mr. Morgan, as described in the Philosophical Transactions for 1786, p. 190. *viz.* that a perfect vacuum, or a space quite void of any substance, is absolutely impervious to the electric matter.

26. Quicksilver does not appear to dissolve in water: but Fourcroy remarks, that Physicians are in the practice of suspending a bag full of it in vermifuge ptisans, during their ebullition; and that experience has evinced the good effects of this practice. Lemery asserts, that there is not any loss of the weight of the mercury in this process; if so, there may issue from this metal some *effluviu*, which is mingled with the water, though so volatile and subtle, as not to diminish, in a sensible manner, its weight. Others, however, assert, that the mercury loses weight in this circumstance.

27. Lastly, mercury has not any taste perceptible by the nerves of our palate; but it, however, produces very remarkable effects on the stomach and intestines of animals, as well as on the surface of the skin. Insects and worms are infinitely
more

more sensible than other animals of this effect: mercury kills them; and physicians employ it not only as a very excellent vermifuge, but as one of the most powerful remedies of the *Materia Medica* for many dreadful disorders, besides those of the venereal kind, for which it is undoubtedly the most singular and effective specific. But they are obliged to disguise it, almost continually, under various forms and denominations; in compliance with the absurd prejudices of the lower and illiberal part of mankind.

28. Even the most virulent product of mercury, known by the name of *Sublimate Corrosive*, already mentioned by the Author, p. 584. which is the most violent poison, is often taken internally in very minute doses, under the direction of skilful physicians, and produces the most happy effects in a great variety of cases, even of the most desperate kind. This is a fact which I have experienced myself, in a dreadful scorbutic complaint I suffered for above four years, with restless and violent pains of the eyes and head. None of the most able physicians in London and Paris I consulted, afforded me any effectual relief, till I had the good fortune to consult Mr. Sacré, surgeon oculist at Antwerp. His prescription consisted of three grains of *sublimate* dissolved in a pint of *common proof spirit*, called of *wine*, though it is, and ought to be, of corn (*frumenti*), or malt spirit; the dose consisted in taking every morning two spoonfuls of it, in a pint of new milk. In less than two weeks, I began to feel relief; and in three months time, I was completely cured. The first methodical practice of this remedy, was communicated to the famous Van Swieten, first Physician to the Emperor's Court, by my late worthy and very much regretted friend Dr. A. R. Sanches, then Archiater, or Chief Physician to the Court of Petersburg, as it appears by the last volume of the Commentaries of the same Van Swieten, p. 550. of the Leyden edition, in 4to, 1772. This volume was published after the Author's death; but he had enjoyed, during his life, the glory of being the author of this wonderful remedy, which continues to bear his name among the ignorant and inaccurate physicians of our times. *The Editor.*

were named after the metals, the number of both being thought equal (*b*).

[*b*] 1. The great *specific gravity* of quicksilver, being in fact the nearest to that of *gold*, and greater than that of any other metal, *platina* only excepted, sufficiently shews, that this metal could not be ranged with propriety among the semi-metals. This gravity is, however, very differently appreciated by various Authors. Bergman, in his *Sciagraphia*, states it to be $\approx 14,110$: and Muschenbroek asserts, that such was the *specific gravity* of the quicksilver that had been sublimed 511 times. This, in all probability, was the same of which Boerhaave speaks in his first Dissertation *de Mercurio*, p. 134. printed at the end of the second volume of his *Elementa Chæmiæ*, Leyden, 1732. But some other authors, among whom is Mr. Fourcroy, reckon this *specific gravity* to be no more than 13,600. Modern experiments show, however, that it generally lays between both, *viz.* about 13,600, or 13 500. This, I am informed, was the mean *specific gravity*, found by the late Lord Cavendish, after the repeated and nice tryals he made upon 50 different specimens of quicksilver, on which he employed all his industry and attention, to determine this point.

2. The hydrostatical experiments I lately undertook of this kind, upon 10 different specimens of mercury, two of which were revived from *native* and *artificial* cinnabar, by the operator of Mr. Kirwan, confirmed me in the same opinion. The temperature of the atmosphere was nearly the mean, *viz.* at the 50th *degree* of Fahrenheit's thermometer; and the scales employed in these operations were so nice, that they turned with $\frac{1}{128}$ of a grain, when loaded with 4 pounds weight.

The method employed, in ascertaining these *specific gravities*, is the easiest of all, and I thought it new, till I afterwards found it had been mentioned by Messieurs Luyart, on their Treatise of the *Analysis of Welfram*. It is as follows:

3. A phial of white glass, with a ground stopple, was counterbalanced with lead, or other matter, in a nice pair of scales. The substance to be tried, was introduced into the phial, and weighed together (suppose ≈ 2). The remaining
space

The opinion, which has a long time prevailed, that the quicksilver is a necessary ingredient, and constituent part in all metals, is not
so

space of the phial being then filled with distilled water, it was again weighed (suppose $=b$).

N. B. Particular care was taken, that no bubble of air remained in the inside. For this purpose a very small groove was made, with a file, on the side of the ground stopple: this was introduced sideways, without admitting any air, leaving room to the superfluous water to rush out. Lastly, the phial was emptied, and cleaned; and, being filled with the same kind of water, was also weighed (suppose $=c$).

It is evident, that $b-a=d$ the quantity of water in the second operation: $c-d=e$ the water equal to the bulk of the substance; and that $\frac{a}{e}$ is the real *specific gravity* sought for.

4. The greatest specific gravity I found among these 10 specimens of mercury, was $=13,620$; and the smallest was $=13,450$. The *heaviest*, was neither of the two that had been distilled from cinnabar; but a common quicksilver I had bought at Apothecaries Hall, in London; and the *lightest* was taken from a barometer of the best and dearer kind, made by one of our most reputed instrument-makers in England.

5. Various may be the causes, which produce the great differences, that are observed sometimes in the specific gravity of mercury. The most obvious seems to be its mixture, or amalgamation with other metals. Certainly, when united to *gold*, its gravity must of course be specifically augmented; on the contrary it must be lessened, when amalgamated with any other metal, *platina* only excepted: and the same must be the event, whenever water, or moisture, is found mixed with mercury (N^o 9. of this same note to p. 615.); for in such a case it will be found heavier after evaporation. A simple boiling of the quicksilver, for some time over the fire, in an open vessel, will compleatly free it from this mixture; and no careful maker of experiments should ever neglect this preparation, before he undertakes to employ mercury in any process, or purpose of the philosophical kind.

so generally received now as heretofore; since those processes, which have been advanced as proofs of it, and which have however but seldom

6. I have hinted already, upon good authority (Note a. N° 2. to Sect. 286.) that mercury becomes not only purer, but *heavier*, after it has undergone very numerous sublimations.

The assertion of Boerhaave, in his dissertation already quoted (N°. 1. of this note), where he says to have examined the *specific gravity* of the mercury distilled 511 times, *per instrumenta irreprehensa et prudentissima sollicitudine*, commanded my belief: but *quandoque bonus dormitat Homerus*; as I found, since the last sheet was printed, that the same respectable philosopher has exposed his doubts on the exactness of that operation, in a second Memoir, he sent, three years after the former, to the same Royal Society of London, which was inserted in the *Philos. Transactions* for 1736, p. 374; where he candidly acknowledges, that having continued to distill that quicksilver till 877 times, its specific gravity, shown by the nice hydrostatic balance of the ingenious Mr. 'sGravesande, appeared to be no more than 13,500, to that of distilled water.

7. Boerhaave died two years after (on the 23d of September 1738); and left his papers to his two nephews, Herman (who died the 7th of October 1753), and Kaw (deceased 5 years after, viz. the 6th of July 1758): after their deaths, these manuscripts fell into the hands of Charles Frederick Kruse, Physician to the Emperor of Russia. This gentleman published a short extract from Boerhaave's Diary, in the 9th vol. of the *Novi commentarii* of the Imp. Acad. of Petersburg, p. 390. The following are the results of this printed extract, which the reader may perhaps be pleased to find in this place.

The specific gravity of the purest gold, to	
distilled water is	19,024
That of mercury, distilled once in a glass retort	13,570
Distilled 1009 times	13,590
4	Distilled

dom been repeated, do by no means succeed, at least not in all places.

It is rather supposed, that by the mercurial earth the ancients must have understood an earth,

Distilled once from its amalgam with gold	13,550
Distilled 750 times from the same amalgam	13,520
Distilled 877 times from the same	13,500
Distilled once from its amalgam with silver	13,550
Distilled 217 times, from the same amalgam, with silver	13,500

8. It is evident, therefore, by these facts, that mercury does not acquire any additional increase to its *specific gravity*, by the mere repetition of its simple distillations, nor by its amalgamations with gold or silver, provided it be afterwards properly separated by fire.

9. In the same manner, when water, or moisture, is found mixed, with mercury, as has been mentioned, N^o 5. of this Note, if the moisture comes to be evaporated, the mercury will remain heavier than before. This process is very easily performed, it only requiring the mercury to be boiled for 20 or 30 minutes, in an open vessel over the fire; as was already mentioned in the same place.

10. There remains still another cause, from which some varieties may arise in ascertaining the specific gravity of quicksilver, as well as of other substances. This is the difference of the temperature of the atmosphere at the time of making the operation. This has been a very material circumstance, which was forgotten or unattended to, by almost all the authors, who have laboured hard to form large tables of the *specific gravities* of numerous substances. Unhappily! for want of this essential circumstance, their labours cannot produce any good effect; and, if not intirely useless, they cannot afford a proper satisfaction in the nice inquiries that depend on this kind of knowledge. The celebrated Christian Wolfius, in his *Elements of Hydrostatics*, Vol. II. p. 263, gives an abstract of Eischenmid's table of *specific gravities*, where it is asserted, that a cubic inch of mercury weighs, in summer, 7 oz.

which may, by addition of phogiston, be reduced in the fire to a metallic state; and this appears to be so much the more reasonable, as

1 *gros.* 66 *gr.*; but in the winter it weighs 20 *gr.* more; *viz.* 7 *oz.* 2 *gros.* 14 *gr.* This, however, leaves the whole nearly in the same uncertainty; since the *mean temperature* between summer and winter is widely different in various climates, and in various local situations; nor is it often the same in every year at each place. So that, unless every time, that the *specific gravity* of mercury, or of any other substance, is taken, the degree of some known and comparable thermometer, such as those of *Fahrenheit*, *Celsius*, or *Reaumur*, be declared, to ascertain the real temperature in which the operation was performed; there cannot be a possibility of forming an adequate idea of the results.

11. Before I dismiss the subject, I must beg leave to give a specimen, or two, of the enormous blunders committed by various philosophers and numerous pretenders, who have been extremely busy in our times, to determine the heights of mountains, and the relative position of places above the level of the sea; by means of barometrical observations, without paying any particular attention to the *specific gravity* of the mercury, with which their barometers were made. If the two barometers were both at 30 inches high, and equally circumstanced in every other respect, excepting only their *Specific gravity* of the quicksilver; so that one be filled with the first kind I have tried, *viz.* whose specific gravity was = 13,62 and the other = 13,45.

In this case, and in all probability many of this kind have often occurred, the error must have been no less than 327 feet; because the heights of the mercurial columns in each barometer must be in the inverse ratio of their specific gravities: *viz.* 13,45 : 13,62 :: 30 : 30,379.

Now the logarithm of 30 = 4771.21

ditto of 30,379 = 4825.73

the difference is = 54.52

which difference shows, that there are 54.52 *fathoms* between one place and another, or 327, *feet*; though in reality both places are on the same level.

12. But

the quicksilver does not attract the metals when in the form of calces.

12. But if the specific gravity of the mercury, in the two barometers, were as the two above mentioned by Bergman and Fourcroy; viz. one of 14,110, and the other of 13,000, which may happen to be the case, as the heaviest is commonly reputed the purest mercury; on this supposition the error must have amounted to 35,576 toises, or above 2134, feet and a half; because $13,000 : 14,110 :: 30 : 32,561$

Now the logarithm of 30 = 4771,21

and that of 32,561 = 5126,97

the difference is = 355,76; which shows that the error should amount to so many fathoms; or 2134,5 feet. *The Editor.*

O R D E R

- c. The least ductile; that is, it cannot be extended or hammered [b] out so much as the others.
- d. In breaking or bending it makes a crackling noise [c].

It

are not mentioned in that table; by means of Wedgwood's new thermometer, which may be easily purchased at the inventor's ware-house, in *Greek-Street* Soho-Square. When tin is heated till almost ready to melt, proves extremely brittle: large blocks of it are, in this state, beaten into pieces from a blow of a hammer. The purer sort, from the facility of its breaking into long shining pieces, is called *Grain Tin*. When melted, if nimbly agitated at the instant of its beginning to congeal, is reduced into small grains or powder. *The Editors*

[b] Tin is so ductile as to be beaten into very thin leaves. But *ductility*, and *extensibility*, are two different properties, less connected with one another than is generally imagined. Iron and steel are drawn into exquisite fine wire, but cannot be beat into very thin leaves. Tin, on the other hand, is beat into fine leaves, and may be extended between rollers to a considerable surface. The tin sheet used in various arts, is commonly about $\frac{1}{88}$ part of an inch; but may be extended twice as much in its dimensions, without difficulty. Notwithstanding this extensibility, tin cannot be drawn into wire, on account of the weak cohesion of its particles. A tin wire, however, of one-tenth of an inch diameter, is able to support a weight of 49 $\frac{1}{2}$ pounds, according to Fourcroy. Gold and Silver possess both properties of ductility and extensibility, the most eminently of all metallic bodies; whilst lead, notwithstanding its flexibility and softness, cannot be made either into leaves or wire of any fineness. *Editor, chiefly from Lewis.*

[c] This crackling noise, which is commonly supposed to be an essential property of pure tin, most probably belongs only to such tin as contains arsenic; for those operations, by which this noxious semi-metal is separated from tin, deprive it of that noise.

Henckel

Henckel discovered a method of separating actual arsenic from tin; namely, by slowly dissolving tin in 8. times its quantity of *aqua regia* made with sal-ammoniac, and setting the solution to evaporate in a gentle warmth. The arsenic begins to concrete whilst the liquor continues hot, and more plentifully on its growing cold, into white crystals. *Lewis.*

Marggraf has given a more particular account of this process in the Memoirs of Berlin for 1747. He observes, that the white sediment, which at first separates during the dissolution, is chiefly arsenical. That the tin of Malacca, though accounted one of the purest sorts, yield no less than one-fourth of its weight of arsenical crystals. That some sorts yield more: but that tin, extracted from any particular ore, which does not hold arsenic, affords none; so that this poisonous substance is but accidentally united to tin. Arsenic may be also separated from tin by means of mercury; for an amalgam of tin being long triturated with water, and the powder, which was washed off, committed to sublimation, a little mercury comes over, and bright arsenical flowers arise in the neck of the retort.

It was in consequence of Henckel and Marggraf's assertions, that the *Lieutenant General* of the Police at Paris gave it in commission to the College of Pharmacy in the year 1781, as Watson relates (Vol. IV. p. 153), to make all the necessary experiments for determining whether pure tin might, or not, be used for domestic purposes, without danger to health? In consequence of this commission, Messieurs Charland and Bayen published their researches, by which it appears, that neither the *East India*, nor the *purest* sort of *English* tin contained any arsenic, though the *English tin* usually met with in commerce, though not really English (See N^o 3. of Note [a] Sect. 304.) did contain so small a portion of arsenic, that it not amounted at most to *one grain per ounce*, viz. $\frac{1}{378}$ of it's whole weight: and that such small portions of tin, as may be mixed with our food, from being prepared in tin vessels, can by no means become dangerous, or at all sensible in the animal œconomy. The large quantities of tin, which are sometimes given internally in medicine with perfect safety, and the constant use our ancestors made of tin vessels, before the introduction of china and other earthen wares, render all other proofs of the innocent nature

- e.* It has a smell particular to itself, and which cannot be described [*d*].
- f.* In the fire it is easily calcined to white ashes, which are twenty-five per cent. heavier than the metal itself. During this operation, the phlogiston is seen to burn off, in form of small sparkles, among the ashes,, or calx [*e*].
- g.* This calx is very refractory; but may, however, with a very strong degree of heat, be brought to a glass of the colour of hard

of tin quite superfluous. *The Editor chiefly from Lewis, Fourcroy, &c.*

[*d*] When friction or heat is employed, the smell of tin becomes more remarkable.

It has also a disagreeable taste peculiar to itself, so very strong, that several physicians have ascribed to it a very perceptible action upon the animal œconomy; and have therefore recommended it in some diseases. *The Editor from Fourcroy and Mongez.*

[*e*] Tin by calcination contracts a brownish grey powder on its surface, which on raising the fire to a cherry red, swells, bursts, and discharges a small bright white flame of an arsenical smell. The metal, when just calcined, appears of a dusky greyish or ash colour; by a long continuance of the fire, becomes white, the more so in proportion as the tin was purer.

Though tin itself is so easily fused, its calx is extremely refractory. Even in the focus of a large burning lens, or of a concave mirror, it only softens a little, and forms crystalline filaments. With glass of bismuth, or with the simple, or the arsenicated glasses of lead, the most powerful fluxes known for refractory calces, it does not perfectly vitrify, forming only opaque milky compounds. By this property it is fitted for making the basis of the imperfect glasses, called Enamels. *Editor from Lewis.*

rosin,

rosin, or *Colophony*. But this calx is easily mixed in glass compositions, and makes with them the *white enamel*.

- b. It unites with all metals and semi-metals but renders most of them very brittle, except lead, bismuth, and zink [f].
- i. It amalgamates easily with quicksilver. See the Note n° 18 to page 608.

[f] Notwithstanding that tin of itself is so soft and so unsonorous, it surprizingly improves the sonorousness, and destroys the ductility, of some of the other metals, particularly gold, silver, copper, and brass. Bell metal, the most sonorous of all metallic bodies, is a composition of copper and tin. The minutest portion, even the vapour of tin, render many ounces, and even pounds of gold or silver, so brittle as to fall into pieces under the hammer. The least particle of tin, falling on the stones or luting of a furnace, will make all the gold and silver melted in it, hard and brittle. On this account Tin is called, by metallurgists, the *Diabolus Metallosum*. Thus far is the assertion of Neumann, p. 125 and 126 Vol. I. of his *Chemical Works*. See also note [i] to p. 519

But it appears, by the experiments of Mr. Alchorne, Assay Master of the London-Mint, that gold, with $\frac{1}{2}$, and even with $\frac{1}{4}$ of tin, does not become brittle. See Phil. Transact. for 1784, p. 464.

Tin, the most fusible, and iron, the most refractory of all the metals, unite easily with one another, and seem to have a great affinity. Iron dissolves by melted tin, in a heat far less than that in which iron by itself melts. The compound is white and brittle. Iron, added to a mixture of lead and tin in fusion, takes up the tin, leaving the lead at the bottom; and, in like manner, if lead, tin, and silver, are melted together, the addition of iron will absorb all the tin, and the tin only. Hence we are furnished with a method of purifying silver from tin, and consequently of preventing the inconveniences, which this metal occasions in the refining of silver by cupellation with lead. *The Editor, chiefly from Neumann and Lewis.*

k. II

- k. It dissolves in aqua regia, the spirit of sea-salt, and the vitriolic acid; but it is only corroded into a white powder by the spirit of nitre [g].

[g] Nitrous acid acts very powerfully on tin. To obtain a perfect solution, the metal must be added a very little at a time, and all heat avoided. If much tin be put at once, the corrosion takes place with great rapidity and heat; and the metal is deprived so much of its phlogiston, that it falls to the bottom in the form of a white calx, insoluble in acids, and of difficult reduction: Macquer acknowledges, that he could never succeed in the attempt. This calx is advantageously employed in making the white enamel. According to Bayen and Charlard, quoted by Fourcroy, from the solution of tin with nitrous acid to saturation (so that the acid be thick and incapable of acting on a new addition of the metal) by washing this mass in a great quantity of distilled water, and evaporating this ley to dryness, a salt *stanno-nitrosus* is got, which detonates alone in a well-heated pot: and burns with a thick white flame, like that of phosphorus. Aqua Regia, made of two parts of nitrous, and one of marine acid, combines with tin; and makes a strong effervescence. The metal must be put in the solvent, only little by little; or else a great part will be calcined. The aqua regia may in that manner be impregnated with half its weight of tin. This solution of tin exalts the tincture of *cochineal*, of *gum-lac*, &c. turning the colour to that of strong fire-red: which is employed by dyers to give the scarlet colour to cloth. It serves also to precipitate the gold from its solution, into a fine purple coloured calx, called *the Powder of Cassius*, its inventor, which serves to give that colour to glass and enamel (See p. 530).

The muriatic or marine acid dissolves tin by means of heat: if it be granulated, and put into a matras over the fire, a small effervescence is produced; when saturated, above half the weight of the tin is found dissolved, and fine crystals may be produced from the solution, by the usual process in similar cases.

The

The vegetable acid, soaps, and pure alkaline salts, also corrode this metal by degrees.

Of all the acids, the marine acid has the greater affinity with tin; but does not dissolve it without heat. It forsakes silver, mercury, and antimony, to unite with tin. When thus combined, it volatilises a considerable part of the metal: and a strong smoking spirit comes over, which, if diluted with water, grows milky, and deposits the tin. This spirit is known by the name of *Fuming Liquor of Libavius*, and is a pure marine acid *charged*, but not *saturated* with tin.

An amalgam of four parts of *tin*, with five of *mercury*, being well triturated in a glass mortar, with an equal weight of corrosive sublimate, the whole is put in a glass-retort, and exposed to a reverberatory furnace, having luted to it a large receiver, with a little hole on the top to give vent, when necessary, to the elastic vapours. The distillation must be begun with a gentle heat. At first a colourless liquor passes over, and a white thick vapour rises, which emits white and copious fumes. This liquor, contained in a phial, discovers no signs of vapour; a certain quantity, however, is disengaged, which deposits the calx of tin in needle-like crystals upon the upper part of the phial; and a small quantity of calx is also precipitated at the bottom, in the form of irregular leaves. It has a very penetrating smell, which excites coughing. This gas of the liquor has but a small degree of elasticity. The residuum, after distillation, presents an amalgam of mercury and tin; and above it a kind of butter of tin, or *stannum cerneum*, which may be volatilised by the force of heat.

Vitriolic acid, according to Neumann, requires to be highly concentrated, and assisted by a boiling heat, in order to dissolve tin. The inflammable principle of the metal, extricated during the solution, unites with a part of the acid into a true sulphur, which sublimes, in its proper form, into the neck of the retort; and a vitriolic acid air escapes during the solution. See Note [a] to p. 491. concerning the formation of Sulphur. The Editor chiefly from Macquer and Fourcroy.

1. Its

- l. Its specific gravity is to water as 7400 to 1000, or as 7321 to 1000 [b].
- m. Dissolved in aqua regia, which for this purpose ought to consist of equal parts of the spirit of nitre and sea-salt, it heightens the colour of the cochineal, and makes it deeper; for otherwise that dye would incline to violet.

[b] The lightest tin is the purest. According to Bergman its specific gravity is = 7264. According to Cotes, Ferguson, and Emerson, it is = 7320. According to Boerhaave = 7321; according to Musschenbroek and Wallerius = 7471; and, according to Martin it is = 7550. But Watson says, that none of the authors he quotes, in estimating the specific gravity of tin, had used the purest sort, but rather a mixture of it with lead: and gives the following table of the weights of various mixtures of tin with lead, by which the *specific gravities* are at the same time known.

One solid Cubic foot of	weighs	ounces Avoirdupois.
Pure lead	-	11270
Pure tin	-	7170
Tin 32 parts, lead 1	-	7321
Tin 16, lead 1	-	7438
Tin 10, lead 1	-	7492
Tin 8, lead 1	-	7560
Tin 5, lead 1	-	7645
Tin 3, lead 1	-	7940
Tin 2, lead 1	-	8160
Tin 1, lead 1	-	8817

S E C T. 298. (Additional.)

Native Tin.

The existence of native tin has long been questioned; but it has undoubtedly been found some years ago in *Cornwall*, as Mr. Kirwan remarks [a].

1. Malleable tin, in a granular form, and also in a foliaceous shape, issuing out of a white hard matter like quartz; but which, after

[a] Our Author said, in his sect. 181, that *tin is not found in the earth in any other state than that of calx, crystallized, &c.* but these words were suppressed in the present edition; because the contrary has been proved by facts, although not known in his own time. Likewise Professor Bergman, in his *Sciagraphia*, sect. 208, published in 1782, says, that some doubts were entertained of the existence of native tin, perhaps not without reason. But this assertion seems rather inconsiderate, as it appears by his own *Theory of the Earth*, published in 1766 at Upsal, and quoted by Dr. J. R. Forster, that he (Mr. Bergman) received an account from Mr. Quist, by which he asserts that Mr. Rinman had seen a specimen of *native tin* in a soft stone, with crystallized quartz, and surrounded with a rind of *tin-zwitter*, or tin-stone. The same Dr. Foster quotes also, in confirmation of this assertion, the vol. XXVII. p. 231. of the *Swedish Transactions*, and the *Systema Naturæ* of Linnæus, vol. III. p. 236. of the 12th edition.

And finally, Wallerius says, that it has been found in the Duchy of *Diuxponte*, in *Cornwall*, and at Malacca in the East Indies. *The Editor.*

being

being properly assayed, proved to be arsenical crystals, a circumstance that evinces its being native tin; since the arsenic could not remain in this form, if the tin had been melted. It appeared like a thick, jagged, or scalloped lace or edging; and was found near St. Austle in Cornwall [b].

2. In the form of crystalline metallic laminæ, or laminated crystals, rising side by side out of an edging, which shone like melted tin; they were almost as thin as flakes or scales of talc, intersecting each other in various directions, with some cavities between them, within which appeared many specks and granules of tin, that could be easily cut with a knife: this was also found in Cornwall [c].

3. In

[b] A specimen of this sort was found in 1765, and sent by Mr. William Borlase, author of the *Natural History of Cornwall*, to the Museum at Oxford, where it may be inspected. It was enveloped by an outer crust, of about one-eighth of an inch thick, of a brownish straw-colour; the second or inner coat was blacker, closer-grained, with some faint appearances of whitish specks, about one-third of an inch thick. Phil. Transact. 1766. p. 36.

[c] The lump or product, of this, and the preceding specimen, was very richly impregnated with tin; and though the best tin-ore, in general, will not melt without flux, nor do twenty pounds of block-tin usually produce more than 14 pounds of the metallic regulus; yet, this tin melted without any flux; and 20 ounces of it produced 16 of good tin, viz. at the rate of 80 per hundred. See the Phil. Transact. vol. LVI. p. 37.

3. In a massy form, more than one inch thick in some places, and inclosed in a kind of quartzous stone: or rather in an hard crust of crystallized arsenic [*d*].

S E C T. 299. (181.)

Calci forme Ores of Tin [*a*].

1. In form of a calx, *Stannum calci forme*.
A. Indurated, or vitrified, *Induratum*.

1. Mixed

This specimen was presented by the same Wm. Borlase, and deposited in the Collection of Fossils of the Royal Society of London, where I saw it many years ago; but it may be now found in the British Museum, where that collection was removed, by a kind of surprize, without the majority of the members being apprized before hand of any such intention.

According to E. M. Da Costa, the tin of this specimen is perfectly ductile and malleable, and bends between the teeth, giving the same cracking noise as tin does. It melts easily in an open fire; calcines in the fire, and emits some smoke: being urged in a strong fire, with borax, it detonates with small phosphorescent sparks, as pure tin does: is corroded to a white calx in nitrous acid, and, by adding oil of tartar *per deliquium*, no precipitation was produced. See the *Phil. Transact.* already quoted. *The Editor*.

[*d*] This was a lump of tin-ore found in a stream work, near the Borough of *Granpont* in *Cornwall*, weighing near 12 pounds; and so well covered by its crust, that, but for its extraordinary weight, it might have passed unnoticed. The fragments still in the possession of Mr. Rosewarne in that place, prove by the granulated external surface, and shotten edge, to be native tin. *Phil. Transact.* for 1766, page 38.

[*a*] These ores are remarkable for their great weight, their specific gravity being from 5,955 to 6,750. *Kirwan*.

IN

1. Mixed with a small portion of the calx of arsenic, *Minera flanni vitrea arsenicalis*.
- a. Solid tin-ore, without any determinate figure. Tin-stone.

It

In order to assay an ore of tin, Fourcroy directs to divide it into different pieces, and reduce them into a gross powder; to separate the earthy part by washing, and to roast the remainder in a covered earthen vessel. In Germany they are roasted in reverberating furnaces, to which an horizontal chimney is affixed to collect the sulphur and arsenic that are found mixed in the ore; the roasted substance is afterwards melted in the air-furnace, and run into moulds in order to form the pigs or blocks of tin for sale.

To assay tin ores in the *liquid way*, has hitherto been thought impracticable; however, Mr. *Bergman* has contrived the following method, which is generally successful. Let the tin ore, well separated from its strong matrix by washing, and reduced to the most subtle powder, be digested in concentrated oil of vitriol, in a strong heat for several hours; to this, when cool, add a small quantity of concentrated marine acid, and suffer it to stand for one or two hours; then add water, and when the solution is clear pour it off; and precipitate it by fixed mineral alkali. 131 grains of this precipitate washed and dried, are equivalent to 100 of tin in its reguline state, if the precipitate consists of pure tin; but if it contains copper or iron, it should be calcined for one hour in a red heat, and then digested in nitrous acid, which will separate the iron.

The Editor from Kirwan.

Almost all the tin ores of Cornwall are in a calciform, and at the same time in an indurated glass-like state. The *Zinnstein*, or *Tinstone* of the Germans, might serve as the general denomination of them; but only the irregular and compact species are called so. The crystallized tin-stones, on the contrary, are called *Zinngraupen*, if the crystals are distinct,

It resembles a garnet of a blackish brown colour, but is much heavier; and has been considered at the English tin mines as a stone, containing

and somewhat large; but *Zinnzwitter* are those in which the crystals are small and not so distinct, resembling small grains, scattered through a compact raw tin-stone, or a stone of any other kind.

These species of Cornish tin-ores differ from those of Bohemia and Saxony, by containing much less *iron*, and less *arsenic*; and this is the cause of the preference the English tin in general obtains, above any other tin, *viz.* on account of its purity.

The common matrix of tin in these mines is the *killas*, already described at p. 261: and the *growan*. This consists of *white clay*, mixed with *mica* and *quartz*, without any particular texture; which, when lamellar and hard, is called *Gneiss* by the Germans; and is nothing else but decayed *granite*, in which the *Feldspar* (Sect. 113.) has been broken down to clay.

The *Zinngraupen* from Cornwall is the most remarkable, though rare. It consists of quadrangular prisms, or double quadrangular pyramids joined by their bases, so that these crystals are octoedral; these are found at *Trevaunance* and *Soil-hole*, in the parish of St. Agnes. Similar prismatic crystals, but of as small a size as a hair, are found in tin-stone upon *Killas*, at Polgooth, one of the richest tin mines, which produces sometimes a clear profit from 1000 to 1200 pounds *per* month.

The *Stream-tin*, is collected in the valleys of the tin-mountains in Cornwall, and yields a considerable quantity of this metal. The soil is dug several feet deep, and washed by water going over it, till the heavier particles of the ore remain at the bottom. These are nothing else but the abrasions of the tin ores over the mountains, which are rolled down the declivities of the hills to lower grounds.

The stream-tin from Penfagillis is remarkable, on account of the native gold now and then met with in it; and found,

containing no metal, until some years ago it began to be smelted to great advantage [b].

found, though very rarely, in pieces of the value of two or three pounds sterling. It principally consists of round, oval, and somewhat smooth pieces, from the size of a bean to that of a pea, and less, whose polished surfaces show a variety of reddish, grey, light-brown, and dark yellow colours.

The *wood-tin-ore* looks like hematites, and is found only in the Parishes of St. Columb, Roach, and St. Denis. This is without any crystallized form; and has a very inconsiderable quantity of iron with it.

Another wood like tin ore, described by Professor Brunnich, shows various fine fibres converging to different centres, like the radiated zeolyte; but is so compact and hard, as to strike fire with steel. Its specific gravity at the 45° of Fahrenheit, is 580, and even 645. It contains some arsenic and a considerable proportion of iron; and gives sometimes 63,5 per cent. of tin. It is very scarce, and found only in small bits. *The Editor from the Treatise of M. H. Klaproth, published when this sheet was going into press.*

[b] The *Tin-stone*, *Zinnstein* of the Germans, *Tenberg* of the Swedes, consists chiefly of stones and sands of different sorts, which contain calx of tin invisibly disseminated through them. Their specific gravity, when the proportion of tin is considerable, is very great. They may be of any colour: The *blue*, *grey*, *black*, or *brown*, are the commonest. They are vulgarly called *lode-stones*.

N. B. 1. The ore called *Weiss Zinngrauen* by the Germans, is that which was mentioned under the calcareous genus by the name of *Tungsten*. (See p. 46 and 47 of this edition;) but this ore contains no tin.

2. When any arsenic is found in tin, it proceeds from it's matrix; for tin itself is never found mineralized by it, but only mixed therewith. And under the same circumstances zinc is sometimes found in tin.

3. It is remarkable that tin has not as yet been found in any stones of the *calcareous* genus, except *fluors*; but in those of the *siliceous* or *argillaceous* kind. *The Editor from Kirwan.*

S E C T. 300. (Additional).

Calci form Tin Ores crystallized [a].

The tin spar, or white tin ore, is generally of a whitish or grey colour; sometimes it is *yellowish, semi-transparent*, and *crystallized*, either of a pyramidal form, or irregularly. It was formerly thought to contain arsenic, but Mr. Margraaf found it to be the purest of all tin-ores; though it is said to contain sometimes a mixture of calcareous earth. Its specific gravity is = 6,007. *Kirwan*.

[a] The Tin-spar resembles a white calcareous spar; but its constituent parts are more compact, and its weight greater. Some writers, and even our author, have doubted whether it contained tin. It is found, though very seldom, at Shlakkenwalde in Bohemia; and contains tin, as I am credibly informed. But there is likewise a heavy mineral very like *tin-spar*, without any particle of this metal in it. *Brunnich*.

Tin ore resembling quartz, I have seen in Mr. De l'Isle's cabinet at Paris. Its colour is white, and it seems to be mineralized by the aerial acid. *Fabroni*.

S E C T.

S E C T. 301. (Part of § 181.)

Tin Grains [a].

This ore like the garnets, is of a spherical polygonal figure; but seems more unctuous on its surface,

1. In large grains.
2. In small grains*.

S E C T. 302. (182.)

Cakes of Tin, mixed with Metals.

1. Tin is found mixed with the calx of iron, as in the garnet. See Sect. 117 [b].

2. Tin

[a] The *opaque, brown, or black tin-ore*, is also crystallized, and imbedded in a strong matrix of quartz, fluor or mica; or mixed with white or yellow pyrites; or in ores of lead or zinc, cobalt, or iron. When these crystals are large, they are called by the Germans *Zinngrauen*, and when small *Zinn-zwitter*. The *black* are reckoned the richest, and afford about 80 per cent of tin. They all contain a mixture of iron. *The Editor from Kirwan.*

[b] Bergman speaks also of ores of tin in the state of calx, contaminated by iron, in the *sect.* 209 of his *Sciagraphia*:

And the *zinn-zwitter* of the Germans already mentioned in the Note to the last Section 209, p. 630; contains also some mixture of iron, as Kirwan asserts.

Wallerius

* See the Notes to p. 629 and 630.

2. Tin mixed with Manganese. *See Sect. 117 of the Author, which will be inserted among the semi-metals.*
3. Tin mineralized with sulphur and iron [c].

Wallerius asserts that the striated tin-ore from Siberia, which has the appearance of amianthus, called by the Swedish *Strålig Tennalm*, and by the Germans *Strahlisches Zinnerz*, is mineralized by arsenic and iron. But this mineralization of tin seems very doubtful, inasmuch, that Kirwan positively asserts, that tin itself is never mineralized by arsenic. *See Note [b] N° 2. p. 631. The Editor.*

[c] The Noble Author had the mistaken, but plausible notion, that *plumbago*, or *black-lead*, was a compound of sulphur, tin, and iron. Indeed the shining appearance of the *aurum musivum*, to be mentioned in Sect. 303, which is a compound of tin and sulphur, was a very specious indication to adopt such a supposition: he had said, in the words that have been suppressed in the beginning of his Sect. 154 (*viz.* 231 of this Edition), *if such a mixture of sulphur, iron, and tin, be not rendered too volatile, it must be supposed that the great loss the blacklead sustains in the calcining heat, is occasioned from the sulphur: and that the sulphur consequently makes out the greatest part of the black lead.* But the true analyses of the *plumbago*, which have been repeatedly made since the Author's time, demonstrate, that black-lead has very different component parts, as was shewn in Section 231; and is also of a very different nature from Molybdena, which the author thought to be only a variety of *plumbago*, it being of a metallic nature, as will be said in its proper place hereafter, among the semi-metals. *The Editor.*

S E C T.

S E C T. 303. (Additional.)

Aurum musivum.

Tin mineralized by sulphur was lately discovered by *Prof. Bergman*, among some minerals which he received from *Siberia* [a]. He observed two sorts of it analogous to the two artificial combinations of tin with sulphur.

1. One nearly of the colour of zinc, and of a fibrous texture, which contained about twenty *per cent.* of sulphur, and the remainder tin.
2. The other enveloped the former like a crust; resembled *aurum musivum*; and contained about forty *per cent.* of sulphur, a small proportion of copper, and the remainder tin. *Mem Stock*, 1721, p. 328. *Quoted by Kirwan* [b].

At

[a] This ore was found at *Nerchinsk* in *Siberia*. The part resembling *aurum musivum*, was the outside crust, and in the middle was a nodule of a white metallic appearance, similar to crude antimony, although it did not contain any. This was radiated from the center outwards; could be easily cut with the knife, after which the surface appeared of variegated colours; and being pounded, produced some black powder. Both these substances were contaminated by a small quantity of copper. *The Editor from Bergman*.

[b] This account of the new ore of tin, given by *Bergman* in the said *Memoirs of Stockholm*, has been translated into French, and inserted in the *Journal de Physique* for

At *Huel Rock*, in St. Agnes in Cornwall, there has been found a metallic vein, 9 feet wide, at 20 yards beneath the surface. Mr. Raspe was the first who discovered this to be a sulphurated tin-ore: it is very compact, of a bluish-white colour, approaching to grey-steel, and

for May 1783, pag. 367. It is directly asserted there, that the proportions of the component parts of this ore, *could not be ascertained*, on account of their minuteness. From hence it is evident, that those proportions, mentioned by Bergman in the *Preface* to his *Sciagraphia*, where he speaks of the same new ore of tin, amount to no more than to a simple guess, from the comparative doses, he mentions in the said memoir, for producing by art two similar substances; the first by melting 20 *per centum* of sulphur with tin in a crucible, which produces a shining mass, like zinc, that has a radiated appearance when broken; but if the quantity of sulphur be double (*viz.* 40 *per centum*), and the fire is stronger, a shining yellow mass is formed, which is composed of very small and thin scales, like the *aurum musivum*, or *mosaicum*, as others call it.

The process given in the London Dispensary, for making artificial *aurum musivum*, consists in melting 12 ounces of tin, in a crucible, and adding, after it is fused, 6 ounces of pure mercury. This brittle amalgam, after being cold, is pounded, and mixed with 6 ounces of sal ammoniac, and 7 ounces of flowers of sulphur. The whole is sublimed in a matras: and the *aurum musivum* will be found in the sublimated matter, and some little drops. Mr. Woulfe says, in the *vol. LXI.* of the *Phil. Transact.* p. 125, that 3 ounces of mercury, and as many of *sal ammoniacum*, is still a better proportion of the above ingredients; and that the *aurum musivum* so produced, amounts then to $17\frac{1}{2}$ ounces, whilst that of the former doses, gives only 16 ounces. This process requires a graduated fire in the beginning, which must be increased, and continued for the space of 5 or 6 hours. *The Editor.*

According

and similar to the colour of grey copper-ore: it is lamellar in its texture, and very brittle. It consists of *sulphur, tin, copper, and some iron*. Mr. Raspe proposes to call it *Bell-metal-ore*[c].

S E C T. 304. (183.)

OBSERVATIONS ON TIN.

It has indeed been asserted by some, that tin is found native in the earth; but, for my own part, like many others, I doubt much of it, having never seen a single specimen that could be called native tin [a].

It

[c] According to Mr. Klaproth's analysis of this ore, 119 grains contain 30 of pure *sulphur*; 41 of *tin*; 43 of *copper*; 2 of *iron*; and 3 gr. of the *Stony matrix*. In another specimen of the same sulphurated tin-ore from Cornwall, there were in the *hundred* 25 parts of *sulphur*, 34 of *tin*, 36 of *copper*, 3 of *iron*, and 2 of the *stony matrix*.

[a] 1. The contrary to this opinion of our author, has been fully demonstrated in *Sett.* 298, *note* [a].

2. Tin, though sometimes unmixed in its ores, is often otherwise; they frequently contain both iron and copper. The fire, with which tin is melted, is sufficiently strong to smelt also the other metals contained in the same ores; and hence, without any fraudulent proceeding in the tin-smelter, there may be a variety of other substances in its mass. But this natural variety is far less than that which is fraudulently introduced; because tin is above five times dearer than lead; and as a mixture, consisting of a large portion of tin with a small one of lead, cannot be easily distinguished from a mass of pure tin, the temptation to adulterate it is great, and the fear of detection small.

3. In

It is, however, remarkable that tin is so scarce, and is not found in any considerable quantity

3. In *Cornwall* the tin, after being smelted from the ore, is poured into quadrangular moulds of stone, containing about 320 pounds weight of metal, and it is then called *block-tin*. The officers, appointed by the Duke of Cornwall, assay it, by taking a piece of one of the under corners of each block; and, if found pure, it is stamped with the seal of the Duchy. It is clear, that if the tin is mixed with lead, this by its superior weight sinks to the bottom, and will be liable to be discovered, when the under corner is employed in the trial. But this seal gives no security for the goodness of the tin sold abroad, since it is known, and Neumann asserts it (p. 131 of his first vol. in 8vo), that in Holland, every tin-founder has English stamps; and whatever his tin be, the inscription *block-tin* makes it pass for *English*. Watson.

4. Whenever the filings of tin, held over the flame of a candle, yield a smell resembling that of garlic; it contains an arsenical mixture: the most part of common tin is in this case; and some think that the crackling noise in bending, which is supposed to be an essential property of pure tin, belongs only to such as is arsenicated; for after those chemical operations, by which the arsenic is separated, the tin is deprived of that noise.

5. Tin melted with arsenic, falls in great part into a whitish calx; the part which remains uncalcined, proves very brittle, appears of a white colour, and shows a sparkling plated texture, greatly resembling zinc. The arsenic is very strongly retained by the tin, so as scarce to be totally dissipated by any degree of fire, though the mixture be urged for a length of time, with a very intense heat. The tin, after being recovered by fusion with inflammable fluxes, discovers, by its appearance, by its brittleness, and by its augmentation of weight, that it still holds a considerable portion of the arsenic. Lewis.

6. Tin exposed to a very violent heat, produces a whitish and brilliant flame; a white smoke rises; which condenses

into

into a whitish needle-form calx, which is called *Tin flowers*. Mongez.

7. Neumann observed, that on mixing iron and tin in the focus of a Tschirnhausen's burning-lens, if the tin was melted first, and the iron added, they united together very quietly; but when the iron was melted first, the addition of tin occasioned a crackling, and a sputtering of little globules, which burst with a considerable snap; and instead of fumes, there arose exceeding fine filaments, which stuck to the cloths, &c. like cobwebs.

8. This kind of detonation, produced by the union of tin with iron on a very violent fire, and the extreme eagerness with which it is attacked by nitrous acid, as mentioned, *see* [g] to Sect. 297. may well account for that curious degradation described by Dr. Higgins in the vol. LXIII. p. 137 of the Phil. Transact. which I have repeated a great many times to some curious persons of my acquaintances. Several small pieces of cupreous nitre (a salt which results from the solution of plated copper in nitrous acid, after evaporation, or nearly so) being put in a piece of tin-foil, with a very few drops of water, and being quickly rolled or wrapped up, with the extremities bent up, and pinched together: 1. the salt deliquesces in the inside of the tin: 2. this salt changes its colour: 3. a froth issues out at the ends of the coil: 4. then a considerable warmth is produced: 5. it emits nitrous fumes: 6. an intolerable heat follows: 7. and at last it bursts with an explosion and fire, fusing the tin-foil in several places. In this case, the acid being moistened, quits the copper, and acts at once on the large surface of the tin, with such an eagerness as to kindle its phlogiston into a blaze.

9. Macquer observed, that putting a good quantity of granulated tin in a matrafs over the fire, the marine acid, which he poured upon it, immediately lost its own fumes; attacked the tin with a sensible but moderate effervescence, and dissolved it to saturation. The solution was as white and transparent as pure water, and dissolved above the half of its weight of tin. When kept for some time in a glass vessel, it crystallized during the cold weather, but became fluid in the summer. Crystals of tin may be formed by the ordinary method, which are of great use in the *calico-printing* processes. *The Editor.*

The

quantity or purity in any other places in Europe, than in England and Saxony [*b*].

It

[*b*] The largest quantities of tin are met with in England, particularly in the county of Cornwall. There is some also in Bohemia and Saxony, as well as in the East-Indies; but in other countries it is rare to find so much as to be worth the trouble and expence of extracting.

2. Britain is supposed to have received its name from its abounding with this metal. For tin being called *Bragmanack*, in the Syriac and Chaldaic languages, that is, the kingdom of Jupiter; from hence seem to have been deduced the words *Bratman*, *Britman*, and *Britania*. Newmann.

3. The uses of tin are very various. It is employed in a great number of arts. Its use, when united to mercury for making looking-glasses, has been already described in note N^o 18. to Sect. 296. p. 608. Bishop Watson seems inclined to believe, on very good grounds, that the art of making looking-glasses, by applying to their back-surface a metallic covering of tin-plate imbibed by quicksilver, is not a very modern invention; and quotes the great Pliny, who asserts, that the Sidonians had invented something of this kind. See vol. IV. of his Essays p. 250.

4. Those metallic plates, generally called *tin* by the English, and more properly *fer-blanc* by the French, are merely iron-plates, very thin, which, on being dipped in melted tin, become quite covered by it, and form a very useful material for making a great variety of vessels and utensils of general use: particularly kitchen vessels, sauce pans, and other implements for the purposes of dressing all sorts of food on the fire. These are the most wholesome vessels, and the only ones that can be employed with safety; whilst those made of copper are highly dangerous, even when newly tinned in the inside; for if any small corner, or part of the surface, escapes the attention of the workman, or if the covering wears out without being observed, some verdigrease may be there generated; and this, when taken with the victuals, never fails of causing terrible effects on the animal body, and often inevitable death. It is much to be wondered indeed!

that

It is likewise worthy of observation, that when its ore is profitable, or to be worked to any advantage

that the numerous disasters that repeatedly happen all over Europe and elsewhere, have not yet determined mankind to exterminate, absolutely, every sort of copper-vessels and all other utensils of copper from their kitchens.

5. It is certain that neither vegetable acids, nor distilled vinegar, dissolve any sensible quantity from tin; and it was on this account that copper vessels for culinary purposes, are generally tinned in the inside, to prevent the poisonous effects of verdegreate being produced, and mixed with the food prepared in such vessels; but, besides the deficiency already mentioned, that may happen in the tinning, the metal commonly employed for this purpose, consists of 5 parts of pewter and 3 parts of lead. Now it is known, that lead is easily attacked by vegetable acids; and if it happens to be taken internally, never fails of producing dangerous and chronic diseases, the *colica Pißonum, pal-fus*, &c. So that after due consideration, *tinn'd iron*, and *tin-plate*, are the only cheap and wholesome materials for vessels for kitchen use.

6. This tin-plate, last-mentioned, is nothing else, but sheets or plates of iron, that have been hammered, or, which is better, flattened to a proper thickness, by passing the hot iron between two iron cylinders cased with steel; they are then cut to a proper size, and steeped in a solution of sal-ammoniac, or in an acid liquor, produced from the fermentation of barley meal, though any other weak acid would answer the purpose; after this steeping, they must be well scoured, so that the whole surface may be very clean and quite bright. They are then dipped into an iron pot filled with melted tin, whose surface is covered with suet, or fat, and pitch. The plates come out with both the surfaces covered with the tin: and as they possess the cleanliness of the tin, added to the rigidity of the iron, they are of great use for many purposes of common life.

7. Pewter, which is commonly called *etain* in France, and generally confounded there with true tin, is a compound

T t

metal,

advantage, it is always in form of an indurated calx, which resembles those glasses that are prepared from metallic calces in our laboratories.

Therefore, in speaking of this resemblance, in order to render this Mineralogical Essay more intelligible to the reader, I have used the term *calx*, in describing the metals; by which word is understood

metal, whose basis is tin. The best sort consists of tin alloyed with about a twentieth, or less, of copper or other metallic bodies, as the experience of the workmen has shewn to be the most conducive to the improvement of its hardness and colour, such as *lead*, *zinc*, *bismuth*, and the metallic, or reguline part of *antimony*. There are 3 sorts of pewter, distinguished by the names of *plate*, *trifle*, and *ley-pewter*. The first is used for plates and dishes; the second for the *pints*, *quarts*, and other measures of beer; and the lay-pewter is used for wine measures, and large vessels.

8. The best sort of pewter consists of 17 parts of regulus of antimony to 100 parts of tin; but the French add a little copper to this kind of tin. A very fine silver looking metal is composed of 100 pounds of tin, 8 of regulus of antimony, 1 of bismuth, and 4 of copper. On the contrary, the *ley pewter*, by comparing its *specific* gravity with those of the mixtures of tin and lead, already mentioned in the table at page 625, must contain more than a fifth part of its weight of lead. This quantity of lead is far too much, considering some of the uses this sort of pewter is applied to; for acid wines will readily corrode the lead of the flagons, in which they are measured, into sugar of lead, which being taken internally, is productive of various chronic diseases, as the *Colica Pictonum*, *palsies*, *stupors* in the limbs, &c.

9. Foreigners generally assert, that English tin is always a mixed metal when exported abroad: and the French Encyclopedists in particular (article *étain*) inform us, on the authority of Mr. Rouelle, that the English tin, when cast into moulds,

understood the same as the chemists call a *crocus*, or *terra metallorum privata*.

The words here suppressed, related to the mistaken notion of the Author already mentioned in Note [c], to Sect. 302. p. 634.

moulds, of 6-inches in thickness, and cooled, if it be divided into 3 layers, the uppermost has 3 pounds of copper on the 100 of tin: the second layer has 5 pounds of lead to the same quantity of tin; and the lowest layer has 9 of lead to the hundred of tin. Geoffroy had formerly given a similar account of the English tin, with some variety in the doses. But there never was any other foundation for such an assertion, than that *pewter* has been mistaken for *tin* abroad: and in fact all pewter-dishes and all other pewter-pieces are called by the name of tin-ware all over Europe, except in England. Nor could there ever be any advantageous motive to hinder the export of pure tin from England, where it is found in a greater abundance than any where else. Besides the above, neither Borlase nor Pryce, who wrote so minutely on the method of preparing tin in Cornwall, mention any operation or mixtures this metal undergoes or receives, before or after it is cast into the slabs, blocks, or pieces of tin, in which *size*, and *form*, it is sold, and sent to every market in Europe; so that the whole must be a mistake in terms, as already mentioned, by taking *pewter* simply for tin.

10. The calx of tin, known by the name of *Putty*, is generally used to polish various hard bodies, as glass, metallic specula for reflecting telescopes, &c. When fused with lead and sand it produces enamel; and serves also to cover earthenware, giving to it a glassy and neat surface for use. *The Editor, chiefly from Watson's Essays.*

S E C T. 305. (184.)

Lead. *Plumbum*, *Saturnus*, Lat. *Bley*, Germ.
Bly, Swed. *Plomb*, French.

General Properties of Lead.

- a.* This metal is of a blueish white colour when fresh broke, but soon becomes dull or tarnished in the air [*a*].
- b.* Is very heavy; viz. to water as 11,325 to 1000 [*b*].
- c.* Is the softest next to gold, but has no great tenacity, and is not in the least sonorous [*c*].
It

[*a*] Lead is not subject to be much corroded by exposure to air or water; though after long standing, a thin crust is formed on its surface, which is a true calx of lead formed by the aerial acid, that slowly decomposes it. *Mongez.*

[*b*] According to Bergman, the specific gravity of lead is = 11,352: Kirwan says, however, that it reaches from 11,300 to 11,479. According to Watson, an English cubic foot of new lead weighs 11,362 ounces of *avoirdupois*; but of lead reduced from *minium*, it weighs 11,460. See the table at page 625.

[*c*] The Author means undoubtedly, that lead is the softest of all metals, except pure gold, with regard to its pliancy or flexibility; but its tenacity is very inconsiderable; and consequently it is incapable of being drawn into a fine wire.

Under the hammer, it is easily extended into thin plates; but its properties, as Nicholson observes, have not induced practitioners

d. It is easily calcined; and, by a certain art in managing the degrees of the fire, its calx becomes white, yellow, and red [d].

This

practitioners to subject it to the same trials as *gold*, *silver*, and *copper*. A wire of this metal, *one-tenth* of an inch thick, cannot hold a weight above 29 pounds and a quarter, without breaking. *Mongez*.

Lead has a remarkable smell, which is very distinctly perceived when rubbed. *Fourcroy*.

[d] Lead, mixed with tin, calcines sooner than by itself alone: one pound of this last quickly incinerates 10 pounds of lead. *Neumann*.

By calcination, lead is converted into a dusky powder called *plumbum ustum*; a longer continued heat, with access of air, renders it *white*, *yellow*, and afterwards it becomes of a *bright red*, inclining to *orange colour*, called *minium*, or *red lead*. The heat for this purpose must not exceed a certain degree. A greater heat converts this substance by degrees, into a *yellow flaky calx*, called *Litharge*; and, by a moderately strong fire, it runs into a *yellow transparent glass*, which powerfully dissolves metallic calces; and, unless combined with these, or earthy additions, corrodes and passes through common crucibles. This glass acts more strongly on *siliceous* than on *argillaceous* earths, and is a principal ingredient in fine white flint-glass. *Nicholson*.

The red-lead, or *minium*, may be made directly from *lead*, and also from *litharge*, which has already been said to be the half vitrified calx of the same metal, and can be had cheaper from various processes where lead is employed. But this last red lead is not so good as the former, on account of the scoria of other substances mixed therewith; particularly the makers of flint-glass, who use much red-lead in the composition of that glass, find that it does not flux so well as that made from the direct calcination of the metal, as practised in the county of *Derby*, where no less than nine mills or furnaces are kept on this operation. These furnaces are very like a baker's oven, with a low

- c. This calx melts more easily, than any other metallic calx, to a glass, which becomes of a yellow colour, and semi-transparent. This glass brings other bodies, and the imperfect metals, into fusion with it.

vaulted roof, and two party-walls, rising from their floor, which leave a middle space, where the pit coal is burned: the flame being drawn over the party walls, strikes on the roof, and is from thence reflected on each side, by which the lead there kept is melted. The surface of lead, by its exposition to air, becomes instantly covered with a dusky pellicle; this is successively removed, and the greatest part of the metal is converted into a yellowish-green powder. This is afterwards ground fine in a mill, and washed; the heterogeneous particles of lead, still in being, are separated by passing the wash through sieves: the yellow colour becomes uniform, and is called *Massicot* by the painters. These yellow calces, being well dried, are thrown again into the furnace, where they are constantly stirred in a continued heat; so that in about 48 hours, these calces acquire a *vivid red* inclining to *orange colour*, and are known by the name of *Minium*, or *red-lead*. Mr. de Machy was certainly mistaken, when he asserted that the calcination alone, without the contact of the flame and smoke, was capable of producing a good colour. But the red-lead made in France is of a considerably worse quality, than what is made in England, or Holland. A ton, or 20 hundred weight of lead, generally gives 22 hundred weight of minium. It is said, that at Nuremberg the increased weight of red-lead amounts to one-fifth of the metal; this may probably depend on the method employed, as Watson thinks. Neumann says, that the best Venetian minium is made out of cerusse, or white lead.

The litharge, already mentioned, is called *Litharge of Gold*, when its colour inclines to *yellow*; and of *silver*, when it is *whitish*; but neither of them contains any portion of these precious metals. Neumann.

It

- f.* It dissolves, 1st, in the spirit of nitre; 2dly, in a diluted oil of vitriol, by way of digestion; 3dly, in the vegetable acid; 4thly, in alkaline solutions; and 5thly, in expressed oils, both in the form of metal and of calx [*e*].
- g.* It gives a sweet taste to all solutions.
- h.* It amalgamates with quicksilver.
- i.* With the spirit of sea-salt it has the same effect as silver, whereby is produced a *saturatus corneus* [*f*].

It

[*e*] Lead dissolves in *nitrous acid* into a yellow liquor. This solution inspissated, explodes or fulminates in the fire. *Neumann.*

Proof *aqua fortis*, lowered with an equal quantity of water, dissolves half its weight of lead. This solution, according to Lewis, being diluted with water, becomes milky, and deposits the metal. But Fourcroy denies this fact in his vol. I. p. 512 of the English edition. The same solution, after exhaling very slowly to the air part of the menstrum, shoots into small pyramidal crystals with square bases, of an austere sweet taste. *Lewis.* Fourcroy says, that these pyramids are hexaedral.

Vitriolic acid, assisted by a boiling heat, corrodes half of its weight of lead into a saline mass. This acid precipitates the metal from its *nitrous* and *marine* solutions. *Lewis*, and *Kirwan.*

[*f*] Pure marine acid, with the assistance of heat, readily calcines lead, and dissolves part of its calx; but it is difficult to saturate it completely. By a strong evaporation, it produces crystals in the form of fine and brilliant needles, according to *Monet* quoted by *Fourcroy*. This metal combines more readily and intimately with marine acid, when this menstrum is poured either uncombined or united with an earthy or alkaline base, into the solution of lead in nitrous acid.

- k. It does not unite with iron, when it is singly added to it in the fire.
- l. It works on the cuppel, which signifies that its glass enters into certain porous bodies, destitute of phlogiston, and alkaline salts.

It

A copious white precipitate is then immediately formed, resembling a coagulum; which is a new combined salt, that falls down, on account of its great insolubility. If exposed to the fire, vapours of a saccharine taste are disengaged: and it fuses into a brown mass, called *Plumbum Corneum*. Fourcroy.

The acetous acid dissolves lead and its calces. *White-lead*, or *ceruse*, is made by rolling leaden plates spirally up, so as to leave the space of an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is some good vinegar. The pots are to be covered and exposed for a length of time to a gentle heat, in a sand-bath; or else they are covered with dung. The vapour of the vinegar attaches itself to the surface of the plates, and corrodes them, reducing the same by that means into *ceruse*, which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly, till they are corroded through.

The acid in the *ceruse* is super-saturated. By a solution of this compound in acetous acid, a crystallizable salt, called *sugar of lead*, is obtained, which is the same as would, with less facility, have been procured by dissolving lead directly in that acid, *Nicholson*.

All solutions of lead are precipitated black by the *liver of sulphur*: and then a sort of *Galena* is formed, the sulphur being deposited upon the calx of lead; which seems to indicate, that the lead, in this ore, is in a calciform state. *Fourcroy*.

The calces of lead are much affected by sulphureous vapours of all kinds. Even metallic salts, which have lead for their base, especially *saccharum saturni*, change colour by the vicinity of such vapours. This solution of sugar of lead may serve as a sympathetic ink. A letter written with it, on being exposed to the vapour of sulphur on lime-water; the
invisible

m. It melts in the fire before it is made red-hot, almost as easily as tin [g].

Its

invisible vapours that rise from it, will blacken the writing, although the letter be put between two or three hundred leaves of paper.

Oils and fats have a strong action on lead, and its calces. Litharge, or any other calces of lead, are copiously and entirely soluble in oils by boiling, which are thereby rendered thicker, and more drying. Linseed oil, thus impregnated with litharge, is much used by painters on the account of the last quality: and is known under the name of *drying oil*. Many of the plasters used in surgery have for their basis an oil thickened by boiling with calx of lead. *Nicholson*.

The topical preparations of calces of lead, known by the name of *Goulard*, have performed wonderful cures in numberless cases, in which other applications have failed. See the excellent *Treatise of Goulard*, in 12mo. London, 1775. The Edit. r.

[g] Lead melts easily on the fire, long before its ignition, at about 595 degrees of Fahrenheit's thermometer, according to Bergman: but Lewis and Nicholson affirm, that 540 degrees is sufficient for the purpose: and that at this degree, its calcination will begin, if respirable air be present in the operation.

By the union of lead with tin and bismuth in a due proportion, a compound metal results, which melts below the degree in which water boils. This mixture has been published by Dr. d'Arcet the celebrated professor of chemistry at Paris. It consists of three parts *tin*, five of *lead*, and eight of *bismuth*. The doses given by Newton, who first discovered this kind of metallic mixtures, and those given by Margraaf and Homberg, require a higher degree of heat to melt. See *Journal de Physique* for March 1777, page 217.

As soon as pure lead melts, its surface is covered with a pellicle, which exhibits various successions of colours; but a small portion of tin or zinc, mixed with it, prevents this variegated appearance. The lead of those metallic sheets, with which the Chinese boxes of tea are lined, does not exhibit,

n. Its calx or glass may be reduced to its metallic state by pot-ashes.

hibit, when melted, those variegated colours on its surface, no doubt on account of its mixture with other metals. The order in which these colours succeed one another, is the following; *yellow, purple, blue*, then *yellow, purple, green*, and twice *pink-green*. All these colours are very vivid with a proper heat; but if that is weak, that succession of colours stops before it has gone through all the above changes. *Watson*.

Melted lead, in a strong red-heat, boils and emits fumes, which the workmen erroneously call *Sulphur*, for they are nothing else but the calcined parts of the metal that sublime of a yellow and red colour. *Watson* affirms, in his essays, vol. III. p. 344, that this sublimate amounts to about *five hundred* weight in one hundred *tons*; viz. 500 in 200,000 pounds, or $\frac{1}{4}$ per centum.

If melted lead be poured into a box, previously rubbed with chalk (to prevent adhesion) and continually agitated, it will concrete into separate grains, of considerable use in a variety of mechanical operations; or, if it be poured into a mould, and turned out at the instant of cooling, a blow with a hammer will break the mass, and the symmetrical arrangement of the internal parts will be seen. *Nicholson*. The like happens also to tin in similar circumstances, as was noted at p. 619.

When melted lead is suffered to cool very slowly, it crystallizes into quadrangular pyramids, laying sideways one over the other. But all metallic substances have been found to have their particular crystallization, of which that of metals approaches to the pyramidical form, whilst that of the semi-metals affects the form of needles, provided they be all properly managed in their cooling, as *Mongez* has shewn in the *Journal de Physique* of July for 1781, p. 74. *The Editor*.

S E C T. 306. (Additional.)

Native Lead. Plumbum Nativum.

Our Author, in the Sect. 191. of this mineralogy and some other mineralogists, doubted whether *native lead* was ever found in its metallic state on the earth; but they never could shew any better grounds for their incredulity, than the deficiency of information; facts however are stubborn witnesses, which cannot be defeated by mere assertions [a].

It appears by the *Phil. Transact.* for 1772, pag. 20, that some small pieces of *native lead* were found in Wales, in the County of *Monmouth*.

Genfanne, in his *History of Languedoc*, p. 208, of vol. III. asserts also, that this metallic substance was found native in the Vivarais. Hence

[a] Bomare mentions (in his *Mineralogy*, vol. II. p. 176.) a curious specimen of *native lead*, kept in the collection of Abbé Nolin at Paris, that had been found in the lead-mines of *Pompean*, near *Rennes* in Brittany. This metal was very malleable; could be cut with a knife without crumbling and easily melted over the flame of a candle. It weighed about two pounds; was imbedded in an earthy lead-ore of a reddish colour: and had a stony vein that went through it. I think, that after such circumstances it can hardly be doubted of its being a natural production. *The Editor.*

kel affirms likewise its existence, in his *Flora Saturnifans*. See Kirwan's *Elem. of Mineralogy*, p. 297 and 298.

Wallerius (p. 301, of the 2d vol. of his *Mineralogy*,) asserts, that this metal has been found in its metallic form, in Poland, a specimen of which was kept in the collection of Richter; and adds, that a similar one, found at Schneeberg, was seen in the collection of Spener.

Dr. Lawson, in his English edition of Cramer's *Art of Essaying Metals*, says, at p. 147, that some *pure native malleable lead* had been lately found in *New England*.

And lastly, the late celebrated Professor Bergman did not hesitate to insert, by itself alone, the *plumbum nativum*, in Sect. 180, of his *Sciagraphia*.

S E C T. 307. (185.)

Calciform Lead.

Lead is found,

A. In the form of a calx, *Minera plumbi calciformis* [a].

Pure,

[a] The calciform ores of lead may be distinguished into 5 varieties; viz. 1. The *white, lead-spar, lead ochre, native ceruse*. 2. *Red, brown, or yellow*. 3. *Green*. 4. *Bluish*. 5. *Black*. All are mineralized by the *aerial acid, or fixed air*:
are

1. Pure, *Minera plumbi calciformis pura*.
 - a. Friable, lead ochre, *Cerussa nativa*, Native ceruse, is found at Kristiersberget in Westmanland, on the surface of the potter's ore [b].
 - b. Indurated, lead spar, or spatose lead ore, *Spatum plumbi*.
1. Radiated, or fibrous.

White, from Mendip-Hills, in England [c].

Crystallised

are soluble in nitrous acid, and effervesce with it, if heat be used, and are dissolved also in expressed oils. All contain a little iron, but never any silver.

[b] Lead ochre, or native *ceruse*, is the same substance; but either in a loose form, or indurated, and shapeless; sometimes it is found in a filamentous form, of a silky appearance. Both contain a little iron, and sometimes calcareous and argillaceous earth: grow red or yellow when sufficiently heated. They effervesce with acids, and afford from 60 to 80, or 90 *per centum* of lead; both are found in *Brittany, Lorrain, Germany, and England*. Kirwan.

Bergman made a separate section of this *cerussa nativa*, which is nothing else but this white lead-ore, mineralized by the aerial acid. See the Sect. 183, of his *Sciagraphia*.

[c] It is there found with the iron-stone and Manganese; but in small quantities. Likewise at Zetterfield in the *Hartz. Brunnich*.

Mr. Sage of the Royal Academy at Paris, pretended that the *white* lead-ore, from Poulawen in the county of *Bretagne* in France, was mineralized by the *marine acid*; but this assertion was demonstrated to be absolutely erroneous by the commissioners of that Academy. See *Journal de Physique*. Tom. III. p. 348. for June 1774.

This ore, according to the same Academicians, is composed of striated crystals, of a whitish pale red, or grey colour. There is a *white lead-ore*, sometimes *grey*, and sometimes *yellow*

2. Crystallized in a prismatic figure [d].

• White, from Norrgrufva in Westmanland.

Yellowish

yellow, which is very heavy. Its structure is either lamellated or fibrous, and its laminae can hardly be separated; but is friable, and may be cut with a knife. Sometimes it is crystallized, and sometimes its fibres are extremely thin, semi-transparent, and of a silky look, as described in the preceding note. They effervesce with acids, decrepitate on the fire, and seem to loose the aerial acid, by which the lead is mineralized. Among the lead mines of France, England, Saxony, and other parts of Germany, many fine specimens of this ore are often to be met with. *Minger.*

[d] The sparry lead has often a semi-transparency like the sparry fluor; its crystals are generally truncated hexaedral prisms, or cylindrical columns, striated, and seem to be composed of a great number of filaments; these sparry crystals are always found in the same places with the *galena* or sulphurated lead ores; and seem to be formed from their decomposition, after the loss of their sulphur; for it is not rare to find *galenas*, which are beginning to pass to the state of white-lead.

Therefore the *black ore* of lead may be regarded as an intermediate species between the *white lead* and *galena*, as it seems to be a true white lead altered by the hepatic vapours of the sulphur, on its parting from the *galena*.

The *green sparry lead* is more or less transparent, and for the most part yellowish. It has frequently no regular form, and appears like a kind of moss.

These lead-ores are found chiefly in Hoffgrund, and near Friburg in Brisgaw. When this green ore is crystallized, it consists of hexaedral truncated prisms, terminated by six-sided pyramids, either intire, or truncated near their base. A great quantity of it is found at Sainte Marie-aux-mines, and at Tschoppau in Saxony. *Fourcroy.*

The *green* and the *black* from Saxony, as well as the *blue* from Hungary, are prismatic. *Brannick.*

The

b. Yellowish green, from Zchopau in Saxony [d].

S E C T.

[d] The *green lead ores* are either crystallized in needles, as in *Brittany*, or in a loose powder as in *Saxony*; but most adhering to, or investing quartz. They owe the green colour to iron, seldom contain copper, and are very rare. *Kirwan* and *Mongez*.

Sapphire coloured. This was once found, together with some white-lead-spar, at *Wendisch-Leuten*; and could be easily melted by the blow-pipe. Dr. Jacquin had this curiosity in his cabinet. *Brunnich*.

This lead ore is sometimes crystallized, sometimes amorphous; it owes its colour to a mixture of copper. *Kirwan*.

Black. This ore is found, though very seldom, in *Saxony*.

The figure of these crystals is not always the same. The *white* ones come near to the shape of the selenite.

Red, or *natural minium*, was found in *Siberia*: and a specimen of it was kept in the collection of the late Prince Charles de Lorraine at *Bruxelles*. *Fabroni*.

Another *red lead* was found in the mines of *Piroosew* near *Catherinenburg* in *Siberia*. *Brunnich*.

The *red*, *brown*, or *yellow lead-ore*, is found either regularly crystallized, or in shapeless masses, or in powder. It differs from the white spar, and from the native ceruse, only by containing more iron. That in powder, contains a mixture of clay. *Kirwan's Mineralogy* p. 299. See also what has been said in the note at p. 524.

Dr. J. R. Forster brought from *Russia* some of this crystallized red lead ore, which I saw on his first arrival in *England*. They appeared to be nearly of a cubical form, and the red-colour was rather pale. *The Editor*.

The *red Siberian* ones are perfectly rhombic; and the *green* from *Bohemia* have a cubical or rhomboidal form. Their colour depends on the adventitious particles. *Lehman* has found sulphur and arsenic in the *red* ones; the others have not been sufficiently investigated: most of them effervesce with acids. *Brunnich*.

The

S E C T. 308. (186.)

Minera plumbi calciformis mixta.

a. Mixed with the calx of arsenic, *arsenical lead spar*.

1. Indurated.

a. White. I have tried such an ore from an unknown place in Germany, and found that no metallic lead could be melted from it by means of the blowpipe, as can be done out of other lead spars; but it must be performed in a crucible, and then that part of the arsenic which did not fly off in smoke, during the experiment, was likewise reduced, and found in form of grains dispersed, and forced into the lead.

Another ore of this kind, which likewise was not easily reduced by means of the blowpipe, did always after being melted, and during the cooling, hastily shoot into poly-

The *black-lead ores* are the most uncommon of all; and occur either crystallized, or of an indeterminate form. *Kirwan*.

A lead ore of a *purplish brown*, nearly resembling the flower of the *peach-tree*, was found at Huelgoet in Brittany. It was a needle-formed crystallization; difficultly fusible with the blow-pipe, and contained more iron than others; but it was easily reduced by the mineral alkali. *Mongez*.

gonal,

gonal, but mostly hexagonal crystals, with shining surfaces. Can this crystallisation be owing to salts, which are said not to act in this manner, but when they are dissolved in water?

b. With calcareous earth [a].

[a] This is the lead ore, described *Minera calciformis mixta terra calcarea majore portione*, of which our author has already treated in his Sect. 37 and 38. It effervesces with aqua fortis, and contains 40 *per cent.* of lead; on which account, it ought rather to be placed here than among the calcareous earths. M. Cronstedt founded his classification upon the Swedish minerals. There are in Scotland, and the northern provinces of England, indurated lead-ochres; but, for want of sufficient experiments, their places in the system are still uncertain. *Brunnich.*

The abovementioned ores are very rich in lead, and easy to be tried; most of them, being slowly heated, may be reduced to lead, by means of the blow-pipe, on a piece of charcoal. The calx of the lead in these ores has, perhaps, first been dissolved by sulphur and arsenic, and afterwards, when these two have weathered away or decayed, have assumed this form; in the same manner as we see it really happens during calcination, with rich lead ores, or such reguli as contain lead. The same, very probably, is the case with other metals; for which reason their ores, when they occur in form of a calx, often contain a little sulphur, and more especially arsenic. *The Author.*

N. B. Most of these ores, mentioned in the notes to the preceding section 307, might as well have been treated of in this place; but it was thought better to set them down according to the references pointed out by Professor Brunnich. *The Editor.*

S E C T. 309. (187.)

Lead mineralized. *Plumbum mineralifatum.*

1. With sulphur alone, *Plumbum sulphure mineralifatum*: The *Bley-Schweiff*, or *Bleyglanz*, of the Germans.
- a. Steel-grained lead ore, from the mines at Hellefors, in the province of Westmanland.
- b. Radiated, or antimoniated lead ore.
- c. Tessellated, or potters lead ore.

At Villach in Austria there is said to be found a potters lead ore, which contains not the least portion of silver.

S E C T. 310. (Additional.)

Lead mineralized by the Vitriolic Acid,

This ore was discovered by Mr. Mounet. It occurs sometimes, though rarely, in the form of a white ponderous calx.

It is soluble in 16 or 18 times its weight of water.

Does not effervesce, nor is it soluble in other acids.

It may be reduced, by the blow-pipe upon charcoal.

It

It seems to originate from the spontaneous decomposition of the sulphurated lead ores mentioned in the last Section.

According to Dr. Withering, another variety of this ore of lead mineralized by *vitriolic acid*, is found in great quantity, in the island of *Anglesey* near Carnarvonshire in England: but it is united to *iron*; and is not reducible by the blow-pipe over charcoal. It is of a yellow colour, and contains some clay. The Doctor promises an accurate analysis of this ore. *The Editor from Kirwan, and Bergman.*

S E C T. 311. (Additional.)

Lead mineralized by the *Acid of Phosphorus*.

This ore was lately discovered by Gahn.

It is of a greenish colour, by reason of a mixture of iron.

Melts upon the charcoal, with the blow-pipe; but does not effervesce with acids.

After solution in nitrous acid, with heat, the lead may be precipitated by vitriolic acid. 137 *grains* of this precipitate, after being washed and dried, afford 100 *gr.* of lead in its metallic state; and the decanted liquor, being evaporated to dryness, produce the *phosphoric acid*: which being mixed with powder of charcoal, affords real phosphorus by distillation.

U u 2

A small

A small piece of this ore, being melted by the heat of a flame, urged by the blow-pipe, assumes the form of a polyédral globule, whose facets, though apparently flat, are really composed of concentric striæ, when observed by the microscope.

Seven ounces of this green lead-ore from Hoffsgund, near Friburg, capital of Brisgaw, in Swabia, being powdered, and dissolved in the nitrous acid, on adding vitriolic acid, this united with the lead, and both precipitated: the remaining liquor being evaporated on a sand heat, to the consistency of Syrup, which was of a green colour, was mixed with powdered charcoal; and, on being urged by fire in a retort, produced about two gros (144 gr.) of a fine phosphorus.

A similar compound may be synthetically produced, if *pure* phosphoric acid, (*viz.* combined with volatile alkali, for the natron of the microcosmic salt hinders the production) be mixed with red-lead. *The Editor from Bergman, Kirwan, and Mongez.*

S E C T. 312. (188.)

2. Lead with sulphurated silver. *Plumbum argento sulphurato mineralisatum.* Galena : Also called *Bleyglanz* by the Germans.
- a. Steel-grained, is found in the mines of Salberg and Hellefors, in the province of Westmanland;

Westmanland; and in the Dorothea-mine, on the Harz in Germany.

- b.* With small scales, is found at Salberg, and is there particularly called *Blyschweif*.
- c.* Fine-grained, found at Salberg.
- d.* Of a fine cubical texture; and,
- e.* Of coarse cubes. These two varieties are found in all the Swedish silver mines.
- f.* Crystallized, from Gislöf in the province of Sköne [*a*].

S E C T.

[*a*] The steel-grained and scaly ores are of a dim and dull appearance when they are broken, and their particles have no determinate angular figure: they are therefore in Swedish commonly called *Blyschweif*, in opposition to the cubical ores, which are called *Blyglanz*.

But, in my opinion, the ores ought to be denominated, and distinguished from one another according to their metallic contents. No ore ought, according to the most received usage, to be called *Blyschweif*, but that which contains only lead and sulphur.

Most part of the ores called *Blyglanz* contain silver, even to twenty four ounces per cent. of which we have instances in the mines of Salberg, where it has been observed that the large diced lead ores are generally the richest in silver, contrary to what is commonly taught in books; the reason of which may perhaps be, that, in making the essays on these two ores, the coarse cubical can be chosen purer or freer from the rock, than the fine cubical ores. *The Author.*

The *galena*, *potter's ore*, *bleyglanz*, and *bleyschweif*, are the commonest of all lead ores. They are of a blueish dark lead colour, formed of cubes of a moderate size, or in cubic grains, whose corners appear to have been cut off. Their texture is lamellar, and of a variable hardness. The hardest sort contain a large proportion of iron and quartz. Those in grains are the richest in silver, and contain about 1 or 1,5 per cent.

that is, 12 or 18 ounces per quintal; the poorest, about 60 grains. Ores that yield about $\frac{1}{2}$ an ounce of silver per quintal, are hardly worth the cost of extracting it. See note [b] to p. 544.

The proportion of sulphur to lead in this ore is also variable, within the limits of 15 and 25 per cent. That which contains the least, is called *bleyschweif*, and is in some degree malleable. The proportion of lead is from 60 to 85 per cent. by reason of an accidental mixture of quartz; and that of iron is generally very small. It was asserted by Monnet, that sulphurated lead ores are insoluble in nitrous acid. Watson affirms, that dilute nitrous acid dissolves them completely.

The specific gravity of galena is from 7000 to 7780; when it is melted, it yields a yellow slag. *The Editor chiefly from Kirwan.*

Galena is found also in a *massy form* without any regular figure. This kind is very frequent at *Sainte Marie aux Mines*.

Galena, with large *facets*, not forming any regular crystals, and quite entirely composed of laminæ, is a very common ore.

That in *small facets*, appears like mica, and consists of small, white, and very brilliant scales. It is called *white ore of silver*, because it contains a great quantity of this metal. Such is that of the mines of Pompean in Brittany.

The galena in *small grains*, mentioned by the author, is very rich in silver.

There are few, except that of Carinthia, which are found not to contain silver, almost all others containing more or less.

It deserves to be noticed, that galenas whose facets or grains are the smallest, yield in general the greatest quantity of silver. It seems that the silver being in some measure a body foreign to the combination of *galena*, deranges the regular crystallization of this ore. See Sect. 278. p. 561 on the silver--pottery-ore.

Galena striated, like antimony, has the external appearance of massy galena; but its fracture exhibits flat and brilliant needles, like that semi-metal.

Finally, galena, crystallized like sparry lead, in hexagonal prisms, or cylindrical columns, is found in the mines of
Huelgoët

S E C T. 313. (189.)

3. With sulphurated iron and silver, *Plumbum ferro & argento sulphurato mineralisatum* [a], is found,

a. Fine-grained.

b. Fine cubical.

c. Coarse cubical. These are found at Wester-silfverberget, in Westmanland.

When this ore is scorified, it yields a black slag; whereas the preceding lead ores yield a yellow one.

Huelgoet in Lower Brittany. This is not rich in silver, and seems to be merely some sparry lead which has been mineralized by sulphur, without having suffered any alteration of form: and indeed there are sometimes observed, upon the same piece, crystals of pure sparry lead, intirely covered with a very fine galena, and others which are quite changed into galena, even in the inner part of their prisms. *Fourcroy*.

[a] The lead ore, described by Kirwan, in his Spec. 7. p. 305, as mineralized by sulphur with silver, and a large portion of iron, called *pyritous lead-ore*, seems to be the same with that described by our Author in this section. Kirwan says, that it is nothing else but a mixture of galena.

The ore, called *pyritous lead ore*, is merely a mixture of galena with *brown pyrites*, of which hereafter among the iron-ores. This is of a brown, or yellowish-dark colour; of an oblong or rhombical form; and of a lamellar, striated, and loose texture. It contains a large portion of iron, and affords at most 18 or 20 *per cent.* of lead, which flows by barely heating it in the fire, as the iron detains the sulphur, allowing the lead to run off. *The Editor from Kirwan.*

S E C T. 314. (190.)

4. With sulphurated antimony and silver, *Plumbum antimonio et argento sulphurato mineralisatum*. Antimoniated or radiated lead ore. This has the colour of a Blyglanz, but is of a radiated texture. It is found,

- a. With fine rays or fibres, and,
b. With coarse rays or fibres.

And is found in Maklos Schacht and Fierde-Bottu, in the mine of Salberg in Westmanland. The lead in this ore prevents any use being made of the antimony to advantage, and the antimony is likewise very injurious in the extracting of the silver [a].

S E C T. 315. (Additional.)

Lead mineralized by Arsenic.

This ore was lately discovered in *Siberia*. Externally it is of a pale, and internally of a deep red colour.

[a] This lead-ore, when-heated, yields a white smoke; and affords 40 to 50 per cent. of lead, and from $\frac{1}{2}$ to 2 ounces of silver in the quintal. *Kirwan*. This is found also at St. *Marie aux mines*. *Mongez*.

For the most part it is crystallized into rhomboidal parallelepipeds, or irregular pyramids.

According to Lehman it contains *sulphur*, *arsenic*, and about 34 *per cent.* of *Lead*. Mr. Pallas says that it contains also some silver.

It was found near *Catherineburg* in *Siberia*: and Lehman says, that on being reduced to powder, it resembles the best carmine.

Mongez examined some, which on the outside was of a yellow-greenish colour; this had been found among quartz in the same country, and contained also some arsenic.

Both these varieties may be easily reduced by the heat of a blowpipe. *The Editor.*

S E C T. 316. (Additional.)

Stony, or Sandy Lead Ores.

This ore consist either of the *calciform*, or of the *galena* kind, intimately mixed, and diffused through stones and earth, chiefly of the calcareous, or of the barytic genus. *Kirwan.*

Of this species seems to be the earthy lead-ore, falsely called *Native Massicot*, found in the lead mines of Pompean in Britany, in the form of solid pieces; they are either yellowish or grey: appear bright like glass when broken: effervesce with acids: whence it appears that this ore is mineralized by the aerial acid, and sometimes it is mixed with clay. *Mongez.*

S E C T.

S E C T. 317. (191.)

OBSERVATIONS ON LEAD ORES.

I know of no native lead; and all that has been said respecting it, is liable to considerable objections. (*See Sect. 306.*)

Such of the potters ores as do not contain any silver are very scarce; yet they are often found so poor in silver, that it does not answer the expences of extracting. These, when they are free from mixtures of the rock, are, without any previous fusion, employed to glaze earthen-ware; and a great trade is carried on in the Mediterranean with such ores, from the lead-mines of Sardinia and France [*a*].

[*a*] 1. In Hungary and Transilvania, the lead-ore contains, besides the silver, a considerable quantity of gold.

Whether lead be mineralized with more metallic bodies than those already mentioned in the preceding Sections, is as yet unknown. The mine of Morgenstern, at Freyberg, has a peculiar variety of lead ore, containing silver, which deserves to be noticed on account of its yellowish-brown colour; and likewise on account of its singular figure, which consists of slender cylinders. *See note [b] to p. 544, on the silver generally contained in lead-ores.*

2. Sometimes it is found growing in dendritical forms, like the *knit-cobalt*.

At Goslar they call a lead ore, mixed with blend, *Brown lead-ore*. Brunnich.

3. Lead

3. Lead unites by fusion to most other metals. A small addition of it makes gold and silver brittle; though a proportional addition of either of these last to lead has the contrary effect, and makes it more ductile. Copper does not unite with lead, unless the lead be red-hot and boiling. After this union, it may again be separated by using a gentle heat, which melts the lead only, which runs off, and leaves the copper. This mode of separating metals by means of their different degrees of fusibility, does not succeed in various other metallic mixtures when fused together.

4. Lead does not unite with iron; but if both are exposed to the fire in a proper vessel, the lead is converted into litharge, which attacks and corrodes the iron, by seizing its phlogiston; and afterwards reduces the martial calces into a dark-coloured glass.

5. This property, which lead possesses, of reducing all imperfect metals into a glassy slag, is the means used to purify gold and silver, neither of which can be thus deprived of its metallic character, but remains untouched at the bottom of the coppel. This process is the more complete, from the efficacy of glass of lead to dissolve all earthy bodies, it being so powerful a flux, that no earthen vessel or crucible can contain it when fused, of whatever materials the vessel be made. A mixture of raw and burned clay stands the action of lead for the longest time; but its sides are also at length corroded.

6. Litharge is employed in the composition of all the finer glasses, called *Pastes*, which imitate *precious stones*. The addition of litharge makes them more solid and brilliant; and enables them to disperse the different coloured rays in a greater degree. The purest flint, purified alkali, borax, and litharge, are the chief and essential ingredients; the other additions, chiefly of metallic calces, are made only for the sake of tinging them of various colours.

7. The white or crystalline glass, called by the name of *flint-glass*, contains a large proportion of lead, which communicates a greater degree of ductility, and a sort of unctuousity, which renders it easier to be worked and polished, &c. It is the purest-calx of lead called *minium*, made immediately from the metal, and the most pure *quartzous sand*, with pure *mineral alkali*, or still better with good *nitre*, that produce, when

when properly melted, the best flint-glass. The greater the proportion is of *red-lead*, the heavier is the glass, and of course its refraction is greater; an essential requisite to be employed in forming the compound achromatic object lenses for astronomical purposes. It must, however, be observed, that glass made with lead has the defect of being of unequal density, for want of a perfect mixture of all its parts; so that it is extremely difficult to find pieces of a few inches diameter among hundreds weight of this flint-glass, that shall be quite free from the filaments and striæ in the inside of the plate. It was by a great chance that the famous Dollond got once a pot of pure flint glass, from which he made the admirable triple object lenses of three feet and a half foot focus, that are in the hands of various astronomers both at home and abroad. But there are already near 20 years that no similar chance has happened again. Many attempts have been made in England and other parts of Europe to remedy this inconvenience; repeated and very considerable premiums have been offered to find the method of producing the fittest kind of this flint-glass for optical instruments; but they have not yet succeeded according to the public expectation.

8. Lead is of very extensive use, as when employed in sheets of a proper thinness for covering buildings, for making pipes to convey water, cisterns or reservoirs for keeping the same; to make statues and busts for the ornament of gardens, for securing iron bars in hard stones, and for sundry kinds of vessels for evaporation, &c.

9. Sheets of lead are made by passing this metal, whilst cold, between two cylinders, or rollers of iron, by which means their thickness is rendered quite uniform, as smooth as the rollers themselves, and of the desired thinness. This is called *milled lead*; but it is harder, and more brittle, than cast sheet-lead, which may be safely bent in any way without forming any crack. Doubtless this is the reason why plumbers say, that *milled lead*, although it may form a neater and lighter work, will not last so long. The *cast sheets* of lead are made by pouring this metal, when fused, upon the top of an inclined flat table, or mould formed with lateral rising borders. If the sheets are required to be thin, the bottom is covered with a woollen, and above this a linen cloth, which is not burned nor scorched thereby. The melted lead
being

being received in a wooden case without a bottom, and of the same width of the table, this case is drawn down over the sloping bottom by a man at each side, and leaves a sheet, more or less thin, according to the degree of the velocity of its descent. But for making thicker sheets of lead, the bottom of the said mould or table is covered with wet sand, and the fused metal is conducted over it by a wooden strike, which bears on the borders of each side.

10. Common shot is made, by pouring melted lead into an iron box, perforated with small holes in the bottom, through which it runs into a vessel of water; but as it forms itself into a kind of drops, in the shape of pears, a small quantity of orpiment, or of white arsenic, is mixed with the metal, by which means it becomes harder, and assumes the form of more perfect spheres. Those which are not sufficiently so, are separated from the rest, by making the whole run straight down in an inclined plain, and those which are irregular tumble off at the sides. After this the shot is sorted, by passing through sieves of different sizes.

11. Lead exposed to the air tarnishes so much more easily, as the air is more humid: it contracts a white rust, which the water gradually carries off. Water in fact alters lead, particularly if charged with saline matters. Caustic alkaline lixivia, boiled on vessels of lead, dissolve a small portion of it, and corrode a considerable quantity of the same. Even the sides of the vessels, for carrying water, are covered with a whitish crust, which has been examined, and is found to be a true calx of this metal.

12. It has been observed, that plants do not thrive so well in leaden, as in earthen vessels.

13. All the phenomena of the calcination of lead, and of its reduction to the metallic state, evidently shew that it has the smallest adhesion to phlogiston, as appears by the simple action of fire, which separates both, whilst their attraction is equally as quick in its reduction to the metallic state. A common red wafer, which owes its colour to red lead, by being burned in the flame of a candle, immediately exhibits pure globules or little drops of the reduced metal. The curious experiments made lately at Paris, by Doctor Luzuriaga, pensioner of the Court of Spain, gives another evident proof of the readiness with which lead parts with its phlogiston.

phlogiston. He put 4 ounces of lead shot, wetted with water, into a pint bottle filled with *atmospheric air*, and closed with stopple; he shook it various times; a black powder was produced, which soon turned white; at the end of 24 hours, on opening it, inverted in a basin of water, the air had lost the fifth part of its bulk, and was quite *phlogisticated*. The same happened with *dephlogisticated air*; but its bulk was still much more reduced; the contrary happened, however, when the experiment was made with *inflammable air*, which, if it is not *phlogiston* itself, is at least greatly loaded with it. *Journ. de Physique* for Oct. 1784, p. 256.

14. The effects of lead on the human body, if internally taken, are very dangerous. Those who are long exposed to its vapours when melted, even those who grind its *calces*, as *minium*, *ceruse*, and *litharge*, for painters, are subject to violent gripes, and constipations of the bowels, contractions of the limbs, and other disorders. Culinary vessels, lined with a mixture of tin and lead, which is the usual tinning, are apt to communicate to acid foods, sour broths, sauces, syrups, and other alimentary preparations, with juice of lemons, or other vegetable acids, very pernicious qualities, chiefly if they are suffered to stand long on the vessels; and the more so, if the persons are of an irritable habit by their bodily constitution. At any rate this metal, when received into the stomach and intestines, even of the most robust persons, occasions violent colics, frequently accompanied with vomiting of green bile, and remarked for the flattening of the belly and depression of the navel. The antimonial emetics and purgatives are used in these cases with success. Navier recommends the different *livers of sulphur*, in cases of persons poisoned with *lead*, as well as with *arsenic*, and *corrosive sublimate*. It is particularly successful in the palsy and tremors, which generally attend those who have laboured under the *Collica Pictonum*. The *Editor*, from *Newman, Watson, and Fourcroy*.

15. In Holland, and perhaps in other places, it has been customary to correct the most offensive expressed oils, as that of *rape-seed*, and rancid oils of *almonds*, or of *olives*, by impregnating them with lead, which mixture renders them very pernicious to health, if taken internally. This dangerous abuse may be discovered, if suspected, by mixing a little of that oil with a solution of *orpiment* made in *lime-water*;

S E C T. 318. (192.)

Copper [*a*], *Cuprum*, *Æs*, *Venus*.*General Properties of this Metal.*

This metal is,

a. Of a red colour.*b.* The specific gravity of the Japan copper is 9000, and of the Swedish 8784 or 8843 to 1000.

It

water; for, on shaking them together, and suffering them to rest, the oil, if it has any saturnine tint, will appear of an orange-red colour; but if pure, it will appear of a pale yellowish one.

16. The same abuse has been also practised with *acid-wines*, which dissolve so much lead, or fugar of lead, as to acquire a sweet taste; but it then becomes a slow poison to those who drink it. This may, however, be discovered in a similar manner; and it is upon the same principle that the *liquor probatorius* is made, to ascertain the fact. This *liquor* is nothing else than a solution of *orpiment*, or of *liver of sulphur* in *lime-water*. If a few drops of this solution be put in a glass of the suspected liquor, it will exhibit a precipitation like a cloud of a dark colour. *The Editor from Fourcroy, Newman, &c.*

See the Notes to p. 589, on the pretended power of fumes of lead to reduce quicksilver into a fixt metal, like silver.

And the note to p. 592, on the imaginary existence of mercury in the metallic substance of lead.

[*a*] 1. Copper is an imperfect metal, of a peculiar reddish-brown colour, and brilliant enough; but it is subject to tarnish: it has a disagreeable smell, perceptible upon friction,

- c. It is considerably soft and tough.
- d. The calx of copper being dissolved by acids becomes green, and by alcalies blue.
- e. It is easily calcined in the fire into a blackish blue substance, which, when rubbed to a fine powder, is red; when melted together with glass, it tinges it first reddish brown, and afterwards of a transparent green or sea-green colour.

It

tion, or on being heated; its taste is styptic and nauseous, less sensible, however, than that of iron.

2. It is of a very considerable hardness, tenacity, ductility, and malleability; and its elasticity is greater than that of any metal, except steel.

From this last property, masses of this metal emit a loud and lasting sound when struck, and this more especially when of a proper figure; viz. if it be such that the metal may vibrate in the simplest manner possible. Thus if it be cast into the hollow form of a bell, without any cracks or imperfections, an uniform tone will be produced by it; or at least the tones produced by the stroke will consist of one predominant tone, and of others that have a musical agreement with it.

3. It has so vast a tenacity, that a wire of a tenth of an inch in diameter, is capable of supporting 299,5 pounds weight, before it breaks. Copper may be drawn into very fine wire, and beaten into extremely thin plates. The German artists, chiefly those of Nuremberg and Augsburg, are said to possess the best method for giving to these thin plates of copper, a fine yellow colour like that of gold, by simply exposing them to the fumes or vapours of zinc, without any real mixture of it with the metal. These plates are cut into proper sizes; then are beaten as thin as leaf of gold; and put likewise into books of paper, which are sold all over Europe, in large quantities, and at a very low price, for the vulgar kinds of gilding.

The

f. It dissolves in all the acids; viz. The acids of vitriol, sea-salt, nitre, and the vegetable; and likewise in all alkaline solutions. That it becomes rusty, and tarnishes in the air (a consequence of a solution having preceded) depends very much on some vitriolic acid which is left in the copper in the refining.

4. The parings, or shreds of these very thin leaves of yellow copper, being well ground on a marble plate, are reduced to a powder similar to gold, which serves to cover, by means of some gum-water, or other adhesive fluid, the surface of various mouldings or other pieces of curious workmanship, giving them the appearance of real bronze, and even of fine gold, at a very trifling expence; because the gold-colour of this metallic powder may be easily raised and improved, by stirring it on a wide earthen basin, over a slow fire.

5. In some of its states, copper is as difficultly extended under the hammer as iron; but proves softer to the file; and never can be made hard enough to strike a spark with flint or other stones, from whence proceeds the use that is made of this metal for *chisels, hammers, boops, &c.* in the gun-powder works.

6. When this metal is broken, by often bending it backwards and forwards, it appears internally, of a dull red colour without any brightness, and of a fine granulated texture; not ill resembling, as Cramer observes, some kinds of earthen-ware.

7. Copper continues malleable in a red heat, and in this state extends much more easily than when cold; but it wants that valuable quality of iron, of cohering together, so as to weld, or join together two pieces of it into one, though equally heated.

8. At a degree of heat far below ignition, the surface of a piece of polished copper becomes covered with various ranges of prismatic colours, the red of each order being nearest to the end, which has been most heated.

refining. This metal is more easily dissolved when in form of a calx than in a metallic state, especially by the acids of vitriol and sea-salt, and the vegetable acid.

- g. Vitriol of copper is of a deep blue colour; but the vegetable acid produces with copper a green salt, which is called *verdigris*.

It

This last effect, proceeds from the beginning of the calcination on the outer surface, the calx being thicker where the heat has been greater, and decreasing thinner and thinner towards the cold part. This explanation coincides with the appearance of that succession of coloured rays formed round the point of contact, between a convex and a plane surface of transparent glass; where the red colour is seen, in each set, towards the thicker angular space that stands between them.

9. This metal reduced into a fine powder, or copper-slings, if thrown across the flame, give *blue* and *green* colours. On account of this property, they are used in fireworks.

10. When the melted copper produces a flame tinged of a *green*, *blueish*, or *rainbow-colours*, it is a mark that the metal burns, and begins to scorify. The heat continuing to increase, the calcination proceeds more rapidly; and powdery scales are formed on its surface, which may be easily rubbed off. This powdery scoria, or calx, cannot be reduced in the greatest heat of common furnaces; but on being exposed to the focus of a good burning lens, the solar rays melt it into a *deep red*, and almost *opaque glass*.

11. Copper melts in a strong white heat, rather less than what is required to melt gold or silver; as may be seen in the table at page 230; although various metallurgists say, that this melting heat is superior to that required for fusing these two noble metals.

When melted, if afterwards it is left to cool very slowly, it forms itself into pyramidal crystals, which are sometimes solid,

- b.* It may be precipitated from its solutions in a metallic state; and this is the origin of the precipitated copper of the mines, called Ziment copper. See Sect. 323.
- k.* It is not easily amalgamated with quicksilver; but requires for this purpose a very strong

solid, and sometimes composed of smaller ones, adhering side-ways to one another.

12. When copper is in a liquid state, it is remarkably impatient of moisture. The contact of a little water occasions the metal to explode, throwing itself about with the utmost violence, to the great danger of the by-standers. There is the same danger in melted brass, or bell-metal, or any other mixture, whereof copper makes a part; so that founders of all sorts should be equally cautious in this respect. Cramer recites a melancholy accident of this kind, which happened at the brass-foundry in *Windmill-hill*, near *Moorfields*, *London*, about 20 years before the time he wrote his work; when several people of quality were invited to see the casting of two large-brass-cannon at a time. The heat of the metal of the first-gun, drove so much damp into the mould of the second, which was near it, that as soon as the metal was let in, it blew up with the greatest violence, tearing up the ground some feet deep, breaking down the furnace, untiling the house, killing many of the spectators on the spot with the streams of melted metal, and scalding many others in a most miserable manner. Copper may, nevertheless, be granulated like other metals, by cautiously pouring a very little at a time into water, as will be mentioned in the note [c] to Section 332.

13. The *vitriolic acid* does not act on copper, unless concentrated and boiling: during this solution a great quantity of sulphureous gas flies off; afterwards a brown thickish matter is found, which contains the calx of the metal, partly combined with the acid. By solution and filtration, a blue solution is obtained, which being evaporated to a certain degree, produces, after cooling, long rhomboidal crystals, of

strong trituration, or the admixture of the acid of nitre.

- k. It becomes yellow when mixed with zink, which has a strong attraction to it, and makes brass, pinchbeck, &c. See Sect. 332. Note [e].

It

a beautiful *blue* colour, called *vitriol of copper*; but if this solution be merely exposed a long time to the air, it affords crystals, and a *green calx* is precipitated, a colour which all calxes of this metal assume, when dried by the air.

14. *Blue vitriol*, however, is seldom formed by dissolving the metal directly in the vitriolic acid. That sold in the shops is mostly obtained from *copper pyrites*. It may also be made by stratifying copper-plates with sulphur, and cementing them together for some time; because the vitriolic acid of the sulphur, being disengaged, attacks and corrodes the metal, forming a metallic salt, which, by affusion of water, yields perfect crystals of *blue vitriol*. This salt has a very strong styptic taste, approaching to causticity. It fuses in the fire, loses its water of crystallization, and becomes of a bluish-white colour: it requires a much stronger heat to separate the vitriolic acid, which adheres more strongly to copper in this salt, than to iron in the *green vitriol*.

15. The *nitrous acid*, on the contrary, dissolves copper, when cold, with great rapidity; and a great quantity of smoking air, or gas, flies off, which, on being received in a pneumatic apparatus, and mixed in a glass-tube, with atmospheric air, shews its good or bad quality for the respiration of living animals, accordingly as the common bulk is more or less diminished. This is one of the most important discoveries made by the great philosopher Dr. Priestley. Various instruments known by the name of *Eudiometers*, have been since invented for making these experiments with ease and satisfaction, if properly managed. The more the bulk of the two airs is diminished, the better the atmospheric air is for animal respiration; on the contrary, the worst air

- l. It is easily dissolved by the glass of lead, which is coloured green by it.
- m. When this metal is exposed to the fire, it gives a green colour to the flame in the moment it begins to melt, and continues to do so afterwards, without losing any thing considerable of its weight.

It

is that, which diminishes the least after its being mixed with the *nitrous air*.

16. This nitrous solution of copper is of a greenish-blue, although Fourcroy calls it a *deeper* blue than that by the vitriolic acid. If evaporated with precaution, it crystallizes by cooling; and produces elongated parallelograms; if the evaporation be quickly performed, the prisms are hexaedral, and resemble bundles of diverging needles; but by a strong and quick evaporation only, an irregular mass is produced. This salt has a caustic taste, and is applied to corrode excrescences on the skin: it detonates, though not strongly, over burning coals. When it is dry, if it be placed in a heat not much greater than the hand can bear, it takes fire. A small quantity of this salt, being put in a piece of tin-foil, wetted with a few drops of water, and instantly wrapped up, the two ends being folded close, in a few seconds produces a great heat, emits strong nitrous vapours: and a deflagration takes place, bursting with a crackling noise, and throwing out sparkles of fire, after which a grey calx remains behind, as has been already described in the note N° 8. to page 639.

17. The *marine acid* dissolves copper only when concentrated and boiling; it assumes a deep green, almost approaching to a *brown* colour. This combination produces a mass very soluble in water; this last becomes of a fine *green* colour, which distinguishes it from the two preceeding solutions by the vitriolic and nitrous acid. This marine salt of copper is of an agreeable grass-green colour, is caustic, and of a very stringent taste. The air, or gas, that is produced by the

X x 3

action

- n. It requires a strong degree of heat before it melts, though less than iron.

S E C T. 319. (193.)

Native Copper, *Cuprum Nativum*.

Copper is found in the earth,

A. Native, or in a metallic state; Virgin or native copper, *Cuprum nativum*.

1. Solid, *Solidum*, is found in the iron mine of Hefslekulla, in the province of Nerike, and at Sunnerfkog, in the province of Smoland; also in the Russian Carelia, and in other foreign places [a].

Friable

action of marine acid on copper, has not been well examined, as Fourcroy remarks; it seems, however, to be of the inflammable kind. Vegetable acids, alkalies, and oily or fat substances, act also on copper. The dangerous consequences of these solutions will be mentioned in Sect. 332.

18. Copper grows *black* or *brown* by long exposure to the air, which acts upon it the more easily when it is moist or altered; and forms upon its surface a *green* rust or calx, which seems of a saline nature; since it has taste, and is dissolved by water. But this rust only attacks the surface of the metal, and even serves to its preservation, as we may learn from the antient medals and statues, which are well preserved under this coat or rust which covers them. The antiquaries call this *crust* by the name of *patine*; and value it greatly, as a mark of the great antiquity of the pieces covered therewith. *The Editor* from Kirwan, Nicholson, Fourcroy, Newmann, &c. See the notes to Sect. 332. concerning the uses of copper, and its poisonous qualities, when taken internally.

[a] 1. Native copper, viz. copper in a more or less malleable state, and either of its own peculiar, or of a grey or

2. Friable in form of small, and somewhat coherent grains; *Cuprum nativum particulis conglomeratis distinctis*. Precipitated or Zimment Copper. It is found at Riddarhyttan in Westmanland, at Fahlun in Dalatne, and in Hungary.

It has been observed, that both copper and the vitreous silver ores after settling from water, are loose, or in grains; but that they in time grow

or blackish colour, has been found either in grains, or in large shapeless solid lumps, or in a foliated, capillary, arborescent form; or crystallized in quadrangular pyramids, on clay, flint, quartz, fluors, zeolytes, &c. in Siberia, Sweden, Germany, Hungary, Transylvania, &c.

1. It undoubtedly has sometimes been produced from precipitation by iron, from water in which it was held in solution; and this is the purest sort. But in many cases it could not have been produced in that manner; and then this sort is never very pure, but mixed either with gold, silver, iron, or with sulphur: This last combination forms what is called black copper. Kirwan.

3. Native copper is found in very considerable quantities at Cape Lizard in Cornwall: it is formed into threads or branches, and veins of some thickness, contained in blackish serpentine mixed with brownish red, and covered externally with a greenish nephrites, partly adherent to it, and partly loose. In the same rocks also, native copper has been found in large lumps.

4. But a more considerable quantity of native copper is found at Huil-virgin in the same province; it shoots into various branches, and in various directions; they seem to be formed of small rhomboidal crystals, interspersed with quartz, of which the impressions are to be seen in the copper itself; from whence it might be concluded the prior existence of the quartz before the formation of the metal. Some of these lumps of native copper have been found in this spot that

X x 4

weighed

grow solid and ductile; whence the dispute about the distinction between *native* and *precipitated* copper may cease, the rather as *native* copper will scarcely be found in other places, and in any other kinds of stones, than those through which the ziment or vitriolic waters have circulated; although the fissures through which it has run, may afterwards be filled with a stony substance.

weighed from 20 to 30 pounds; and only in the month of March 1785, there were extracted from this mine no less than 1400 tons, *viz.* 2800000 pounds weight of rich copper ore.

5. At the place called *Carrarach*, which is contiguous to *Huel-virgin*, and which is not a less rich mine, some crystallized native copper was found, with the transparent vitreous copper ore, of a ruby colour, crystallized in octahedrons; but this fine red-crystallized vitreous copper ore begins to be very scarce there.

6. Near the copper vein at *Carrarach*, is found also a compact native copper, of a spherical form, in lumps; the copper, either is still in its metallic form; or is beginning to be transformed into red copper-glass, imbedded in decayed granite.

7. Native copper, of a tender and moss-like form, united to vitreous ruby copper-ore, crystalized in rhombs, is found in the clefts of the mountains composed of killas, near Poldry. *The Editor from M. H. Klaproth's Observations on ores of Cornwall.*

8. An indurated iron-clay has lately been found under the surface of the sea, in the Faroe Isles, in which there is scattered a zeolite, with *native copper*. Brunnich.

S E C T. 320. (194.)

Calcifform Ores of Copper.

B. In form of a calx, *Minera cupri calciformis*.

1. Pure, *Minera cupri calciformis pura*.

a. Loose or friable, *Oebra veneris*.

1. Blue, *Cæruleum montanum* [*a*].

Is

[*a*] 1. This, and the two following ores of copper, are mineralized by the aerial acid; they are soluble in acids, and blacken in a moderate heat. The first is called *mountain-blue*, though some call it by the name of *Chrysoerlia*, and the Hungarians give it the name of *lapis lazuli*; but this last is a true zcolyte, whose blue colour proceeds from iron, as has been observed already in Sect. 139, and p. 248.

2. The *Mountain Blue* frequently appears in a *loose form*, but sometimes it is *indurated*, and even crystallized: it is then mixed with quartz. 100 parts of it contain about 69 of *copper*, 29 of *aerial acid*, and 2 of *water*. Mr. Morveau has shewn that the calces of copper are determined rather to a *blue*, than to a *green colour*, by a greater proportion of phlogiston. The *Editor from Kirwan*.

3. The *azure* copper ore is also met with on quartz at the mines of *Huel-virgin*, and at *Carrarach* in Cornwall, according to *Klaproth's observations*.

4. Another *Cæruleum montanum*, less pure than the above, will be mentioned in Sect. 322.

We may observe in general, that the copper ores, after roasting, communicate a *blue colour* to volatil alkali, by digestion. Before roasting, it is possible that the mixture of a portion of arsenic, or even sulphur, in a sufficient quantity, may prevent this effect. *Kirwan*.

1. This

Is very seldom found perfectly free from a calcareous matter.

2. Green, *Viride montanum*.

Both these colours depend on menstrea, which are oftenedulcorated or washed away [b].

3. Red [c]. This is an efflorescence of the glass copper ore. It is found in the province

[b] 1. This ore is commonly called *Malachite* when in a solid form. It has the appearance of green jasper; but is not so hard, since it does not strike fire with steel. It is either of a radiated or uniform texture, generally of an oval form, and of the size of an egg; but sometimes it is formed of capillary filaments, like fatten, and shews a kind of concentric stripes, or shreds of paler colours, when cut and polished; its external appearance is like a thick shell, with various protuberances of a mamillary form. The silky green copper-ore of this kind from China, in the form of solid bundles, is the purest. It is found also in great quantity on the Vosges, mountains so-called in Lorraine, and in the mines of the Hartz in Saxony.

2. According to Kirwan, the purest malachite contains 75 parts of copper, and 25 of aerial acid. Its specific gravity, according to *Musschenbroeck*, is from 3,500 to 3,994. It is sometimes mixed with calcareous earth and gypsum; and is found in *Norway* and *Siberia*; &c. Kirwan.

3. Compact green copper ore, like malachite; mixed with grey copper-ore; and likewise green-velvet-like copper, in the form of bunches, is found at Huel-Virgin, in Cornwall. At Carraraeh, in the same county, is found also an amorphous green copper-ore, on a decayed granite; and at St. Menan, the same is found stratified betwixt quartz, and covered with a brownish iron. *The Editor from M. H. Klaproth.*

[c] 1. This red-ore is the *Minera hepatica*, or the *Leberertz* of the Germans: it is found sometimes in a loose form, and is then called *copper-ochre*: but generally it is moderately hard, yet brittle: sometimes is crystallized and transparent,

of Dal, and at Ostanberg, in the province of Dalarne,

S E C T. 321. (195.)

Red Copper-ore,

b. Indurated, *Indurata.*

a. Red, *Minera cupri calciformis pura & indurata, colore rubro.*

This is sometimes as red as sealing-wax, and sometimes more of a liver-brown colour. It is found in Sandbacken, or Norberg in Westmanland, at Ordal in Norway, in Siberia and in Suabia in Germany.

This ore is always found together with native copper, which seems to have lost its phlogiston by efflorescence, and to be changed into this form. It is likewise found with the sulphurated copper, called *Glass copper ore.*

either of a capillary appearance, or in *cubes, prisms, or pyramids.* It is found in *England, Scotland, Germany, &c.*

2. This ore contains 73 parts of *copper*, 26 of *acrid-acid*, and 1 of *water*; and effervesces with acids.

3. The *brown*, or *hepatic* ore of this kind, contains a variable proportion of *iron*, or *pyrites*, and sometimes *sulphurated iron*: and affords from 20 to 50 *per cent.* of *copper.*

4. It is sometimes iridescent in its colour, like the *cat's eye*.
 of the pseudopalus of Sect. 95. *The Editor chiefly from Kirwan.*

S E C T.

S E C T. 322. (196.)

Calciform Copper-ore, impure.

2. Mixed, *Minera cupri calciformis impura*

a. Loose or friable, *Ochra veneris friabilis impura*.

1. Mixed with a calcareous substance, *Ochra veneris terra calcarea mixta* [a]. *Ceruleum montanum*. In this state copper-blue is mostly found. It effervesces during the solution in aqua fortis. See Sect. 40. (34.)

2. Mixed with iron. Black. It is the decomposition of the Fahlun copper ore. Sect. 198. a. of the Author [b].

Indurated,

[a] In Saalfeld they find also a sort of *green*, somewhat indurated calcareous substance, containing copper; this, when broken, looks fat, and somewhat shining; but upon the whole, it resembles a jasper. It is there very wrongly called a *Green Copper Glass-ore*. They make good copper of it. With a phlogistic substance, without being ustulated; it forms a fit mass for bells, or a kind of bell-metal. *Brunnich*.

[b] By the *fahlun copper ore*, is meant the copper ore of a *fallow* or *fallow* colour. *Lewis*.

In some parts, among the native copper-ores from Poldory and Huel-virgin, is found a calciform-copper-ore, sometimes in a loose form, covering them like sand; and some times this forms a compact structure, which adheres strongly to them. The former

b. Indurated, Minera cupri calciformis impura indurata.

1. Mixed with gypsum, or plaster. Green. Is found at Ordal in Norway, and there called Malachites.
2. Mixed with quartz. Red. From Sunnerkog, in the province of Smoland. Sect 91. (53.) B.
3. Mixed with lime. Blue. This is the *lapis armenus*, according to the accounts given of it by Authors [c].

S E C T. 323. (Additional.)

The Cupreous Stones.

Analogous to the calciform copper ores, are the *lapis Armenus*, of which was already spoken in Sect. 41. p. 61: and in the note [c] to the preceeding Section 322. This is very different from the *lapis lazuli*, described in

former kind is generally black; and the latter is of a brownish red, often approaching to the metallic splendor of copper. The Editor from M. H. Klaproth's *Observations on the Fossils of Cornwall*.

[c] The *Lapis Armenus* is a blue stone, which does not admit of a polish, and consists of calcareous earth, or gypsum, penetrated with the blue calx of copper; hence it sometimes effervesces with acids, and sometimes not; but never gives fire with steel. It loses its colour, when well heated in the fire. See Sect. 41 (35) pag. 60. The Editor from Kirwan.

Sect.

Sect. 139. p. 247. among the *heolytes*; since this last contains no copper, as may be seen in the notes to the same Section.

The other cupréous stone is the *Turquoise*; and seems to be the tooth of an animal, penetrated with the blue calx of copper. It loses its colour when over-heated. It is opaque, of a lamellar texture, and susceptible of a fine polish.

Its specific gravity is from 2,5 to 2,908. Some are of a deep blue, some of a whitish-blue, but become of a deeper when heated. These stones are found in *Persia* and in *Turkey*, from whence they received their name. But they are also found in Lower *Languedoc*, in France, near the village *Simore*, where these stones, when dug out from the mine, resemble different bones, teeth, &c. of various sizes; and are either whitish, grey, or yellowish. They receive the blue colour, on being slowly heated to a high degree; but if the fire be long continued afterwards, the colour is irrecoverably lost.

Jewellers divide this kind of stones, or rather bony substances, according to their fanciful method into *oriental* and *occidental* turquoises; ranging the hardest and the finest coloured under the first epithet; and the softest, or of an inferior colour, under the *second* denomination. But although experience shows the fallacy of such distinctions in a great many instances; the old custom nevertheless continues to prevail.

According

According to Kirwan the blue coppery tincture of the turquoises may be extracted from them by distilled vinegar: and Reaumur asserts, that nitrous acid will not dissolve the Persian turquoises, though it will those of France; which, if true, indicates a real difference between them. *The Editor from Kirwan, Neumann, Bomare, &c.*

S E C T. 324. (197.)

Copper mineralized by Sulphur.

C. Dissolved and mineralised, *Cuprum mineralisatum*.

a. With sulphur alone, *Cuprum sulphure mineralisatum*. Grey copper ore. It is improperly called *Glass copper ore*.

a. Solid, without any certain texture, *Minera cupri sulphurata solida, textura indeterminata*. This is very soft, so that it can be cut with a knife, almost as easily as black lead [a].

Fine

[a] 1. According to Kirwan, this is the true *vitreous*, or *glass-copper ore*, the *kupfer glas ertz* of the Germans.

The colour of this ore is *red, brown, blue, or violet*. It is generally so soft, as to be cut with a knife; and as to its form, it is sometimes crystallized in regular forms, and sometimes it is amorphous.

This ore is much more fusible than pure copper. Its specific gravity is from 4.810 to 5.338, and is found in the mines

b. Fine cubical; *Minera cupri sulphurata testulis constans minoribus.*

Both these varieties are found at Sunnerflog, in Smoland; where the last is sometimes found decomposed, or weathered, and changed into a deep *mountain-blue*. See Sect. 320. (194.)

S E C T.

mines of other copper-ores, and in lime-stone, spar, quartz, mica, and clay.

It is the richest of all copper-ores; and affords from 80 to 90 per cent. of copper, and 10 or 12 of sulphur. According to Bergman, it generally contains some alloy of iron. The poorest red ores of this sort, are those which contain most iron. *The Editor chiefly from Kirwan.*

2. There is a great variety of sulphurated copper-ores in the mines of Cornwall. A whitish grey copper-ore, crystallized in small triangular and quadrangular pyramids, with truncated points, is found along with the solid copper ore at Poldice and Dolcoth. But the richest are the *solid grey* ones from Treseavean, Restalack, Cook-Kitchen, Carrarach, Well-Virgin, and Redruth. Some of these may be cut with a knife, like the soft vitreous silver-ore, particularly those from Treseavean.

3. Yellow copper-ores of the kind are found at Poldice, Hallamanning, and Dol-coth. The most remarkable of them is the stalactical ore, of an hemispherical form, called *Run-yellow copper*, found in the mine near Dolcoth, which is 160 yards deep, though elevated more than 60 yards above the level of the sea. This ore is often variegated with the colours of blue steel, or red copper.

4. A compact red vitreous copper-ore, covered with mountain-green, or green copper, and with calciform copper of a vermilion-red colour, is found in crystallized quartz, mixed with tender green mica, in the mine at Kettle Adit.

5. A new kind of an *olive green coloured* copper-ore, which is arsenical, and is crystallized into tender spiculæ, of about
three

S E C T. 325. (198.)

Pyritous Copper-ores.

2. With sulphurated iron, *Minera cupri pyritacea*. Yellow copper ore. Marcasitical copper ore, *Pyrites cupri*.

This is various both in regard to colour, and the different proportion of each of the contained metals; for instance;

- a. Blackish grey, inclining a little to yellow, *Pyrites cupri griseus*. The Fahl copper ertz of the Germans.

three lines long, standing straight up, either single, or fasciculated and radiated, was found also on the granitical mountain at Carrarach. When tried by the blow-pipe, these crystals deflagrate with an arsenical smoke, and afterwards fuse, forming a button of a grey colour, which on being melted again with borax, soon produces a button of a very pure copper.

Besides this new arsenical ore, M. H. Klaproth, from whose *Mineralogical Observations on the mines of Cornwall* these two articles are taken, mentions another kind of arsenical copper-crystals, which are very small, and aggregated in the form of green cubes, with smooth and shining surfaces, upon grey copper ore, in a mass of crystallized compact quartz, with various cavities in itself. These might be easily taken for small cubes of fluor; but their constituent parts are really nothing else but copper and arsenic. *The Editor from Klaproth's Observations on the Mines of Cornwall.*

Y y

When

When decayed or weathered, it is of a black colour; is the richest of all the varieties of this kind of copper ore, yielding between 50 and 60 per cent. and is found in Spain and Germany.

b. Reddish yellow, or liver brown, with a blue coat on the surface, *Minera cupri lazurea* [a].

This ore yields between 40 and 50 per cent. of copper, and is commonly said to be blue, though it is as red, when fresh broke, as a rich copper regulus.

c. Yellowish green, *Pyrites cupri flavo viridescens* [b].

This is the most common in the north part of Europe; and is, in regard to its texture, found

1. Solid, and of a shining texture, from Ostanberg, in the province of Dalarne.

[a] This ore is mineralized by sulphur, with a considerable portion of iron, and is called *kupfer lazur*, and *kupfer malm*, by the Germans.

Its colour consists in various shades of blue and of reddish blue.

It is of an hard consistence, but brittle.

Contains from 40 to 60 per cent. of copper; from 20 to 30 of iron; and the remainder is sulphur.

The poorer it is in iron, the richer in copper.

This has been confounded by many with the indurated Mountain blue of Sect. 322. The Editor chiefly from Kirwan.

[b] This ore presents fragments in its fracture; its specific gravity is 4,160; contains more sulphur; and from 15 to 30 per cent. of copper. Kirwan.

2. Steel-

2. Steel-grained, dull in the fracture, from the same place, and Falun in Dalarne.
3. Coarse-grained, is of an uneven and thinning texture. It occurs in most of the Swedish and Norwegian copper mines.
4. Crystallised marcasitical copper ore.

a. Of long octaedral crystals [c].

This is found at Hevassvik, in the province of Dal, and in Lovisagråva, in Westmanland; notwithstanding its existence is denied by Henckel, and his followers.

d. Pale yellow, *Pyrites cupri pallide flavus* [d].

This cannot be described but as a sulphur pyrites, though an experienced eye will easily discover some difference between them. It is found at Tunaberg, in the province of Södermanland, and yields 22 per cent. of copper.

e. Liver-coloured.

This is found at Falun, in Dalarne, where it contains copper; though at most other places where it occurs it does not contain any copper, but is only a martial marcasite.

[c] This crystallized sort is the poorest in copper, it contains only from 4 to 8 per cent. the remainder is chiefly iron: it is generally reddish, and is in fact a martial pyrites, with a small portion of copper. *Kirwan*.

[d] The pure yellow contains most copper; namely from 20 to 30 per cent. its texture is foliated. These pyritous ores always contain some *argillaceous* earth, and a little of the *silicious*. *Kirwan*.

S E C T. 326. (Additional.)

Pyritous Copper, with Silver and Arsenic.

With sulphurated silver, arsenic, and some iron. *Cuprum argento sulphurato, arsenico et ferro mineralisatum.* Fallow copper-ore.

In Hungary it is called *Black Copper-ore.*

It contains only a few ounces of *silver.*

This ore is found in Hungary and Germany [*a*]. These ores yield a brittle copper regulus.

[*a*] The following natural mixtures of copper-ores, with other metals, have been already mentioned in the preceding sections, *viz.*

Copper with gold pyrites. See Sect. 263. p. 527. Note [*d*] N^o. 6.

with gold and silver, &c. See Sect. 265. p. 544.

No. 2 and 3.

with silver and iron, &c. See Sect. 272. p. 554.

with silver and antimony, &c. See Sect. 276. p. 559.

with mercury, &c. See Sect. 294. p. 601. The Editor.

S E C T. 327. (199.)

Pyritous Copper, with Arsenic, or White Copper-ore.

3. With sulphurated arsenic and iron, *Cuprum ferro et arsenico sulphurato mineralisatum*. White copper-ore [a].

[a] 1. This copper-ore, is called *arsenical*, or *grey copper ore*. *Kupfer Fablertz*, or *Weiss Kupferertz*, by the Germans.

It is of a *white*, *grey*, or *brown* colour; is moderately hard and very brittle.

Sometimes it is crystallized, but often of an indeterminate figure. It is of a very difficult fusion, and pretty heavy.

It contains from 35 to 60 *per cent.* of copper. The *brown* is the richest in copper; the *white* or *grey* contains most arsenic.

It frequently contains silver. If it exceeds 1 or 2 *per cent.* it is then called *grey silver ore*.

It is found embodied in all sorts of stones, and mixed with other copper-ores, as well as with the ores of all other metals. *Kirwan*, p. 266.

This kind of copper-ore is found also in the copper and tin mines of St. Ives in Cornwall, according to the account given by Mr. Raspe: and the Chev. Born mentions the same ore found in Hungary. *The Editor*.

N. B. To assay these ores in the dry way, they should first be pulverised and separated, as much as possible, from stony and earthy particles; then roasted, to separate the sulphur and arsenic; then melted with an equal weight of *Mr. Tillet's flux*, which consists of two parts of *pounded glass*, one of calcined *borax*, and $\frac{1}{4}$ of *charcoal*. If the ore be poor, more borax may be added. Black flux is hurtful, as it forms an *hepar*, which holds part of the copper in solution. *Kirwan*, p. 267.

It is said to be found in the Hartz, in Germany, and to resemble an arsenical pyrites; but I have never met with this kind.

However, most of the pyritous copper ores, as well as the sulphur pyrites, contain a little arsenic, though it is in too small a quantity to be worth notice.

S E C T. 328. (Additional.)

Pyritous Copper, with Arsenic and Zinc.

According to Mr. Monnet, this ore is found at *Catharineberg* in *Bohemia*.

It is of a brown colour; of a hard, solid, and compact granular texture.

It contains from 18 to 30 *per cent.* of copper [a],

[a] 1. It is analysed in the liquid way, by solution in nitrous acid, and precipitation of the copper by iron.

2. The iron and zinc are precipitated by the *Prussian alkali*.

3. The precipitate is calcined and redissolved in nitrous acid, which solution is evaporated to dryness.

4. The iron being thus dephlogisticated, becomes insoluble in nitrous acid.

5. The calx of zinc, on the contrary, is redissolved in that acid, and again precipitated by the *Prussian alkali*.

6. 100 gr. of this precipitate, washed and dried, are equivalent to 20 of zinc in its metallic state; and 100 gr. of dephlogisticated iron are equivalent to 73,5 of iron in its metallic state. *Kirwan*, p. 268.

S E C T,

S E C T. 329. (200.)

4. Dissolved by the vitriolic acid, *Cuprum acido vitrioli solutum: Vitriolum Veneris* [a]. See Sect. 205. (122.2)

S E C T.

[a] 1. In the year 1673, our countryman, Dr. Brown, visited a famous copper-mine at *Hein-grundt*, about seven English miles from Newfol, in the *Upper Hungary*; and he informs us that there he saw two springs, called the *Oil*, and *New ziment*, which turned iron to copper, as it is vulgarly said. But the case is, that the *iron* is dissolved by the *vitriolic acid* of this spring-water, and the *copper* is precipitated, in its metallic form, in the place of the *iron*. It has been the custom in Germany, for some centuries, to collect the copper contained in these waters, by filling with them some pits made purposely for this operation. Old iron is thrown in, and being dissolved by the acid, is suspended in the water, whilst the copper is precipitated: the mud being raked out, is melted afterwards in a furnace, and a very fine copper is produced: from *one hundred* tons of iron, 84, and sometimes 90 tons of fine copper is thus produced

2. But although this method of obtaining copper has been long practised in Germany, yet it is but of late years, says Bp. Watson (p. 238 of the first volume of his *Essays*), that any successful attempts of this kind have been made either in *England* or *Ireland*. In this last at least, it was quite owing to an accident. There are the very celebrated copper-mines at *Arklow*, in the county of *Wicklow*, in Ireland; and from these mines, issues a great quantity of water, strongly impregnated with *vitriol* of *copper*. One of the workmen having accidentally left an *iron shovel* in this water, he found it, some weeks after, so incruited with a coat of copper, that it was thought to be changed into copper

Y y 4

2. The

S E C T. 330. (Additional.)

Copper mineralised by the Muriatic Acid.

This copper-ore was found in Saxony, and had been generally mistaken for a *micaceous*

3. The proprietors of the mines, in pursuance of this hint, made proper pits and receptacles for the water, and have obtained, by means of soft iron bars put into them, such quantities of copper, that these streams are now of as much consequence as the mines themselves. One ton of *iron* produces near two tons of copper mud; and each ton of mud produces, when melted, 16 hundred weight of copper, which sells for 10 *pounds sterling* a ton more than the copper which is fluxed from the ore.

4. There is in the Isle of *Anglesey*, on the coast of North-Wales, a mountain called *Paris*, which abounds in copper-ore, the bed of ore being above 40 feet in thickness. The lessees of this mine annually raise from 6 to 7 thousand tons of merchantable ore, and daily employ above 40 furnaces in smelting it. This ore contains great quantity of sulphur, which must be separated by roasting, before it can be fluxed into copper. The phlogiston, with part of the vitriolic acid, is dispersed into the air, by the force of the fire; another part of the acid attacks and dissolves such a quantity of the copper, that the water in which the roasted ore is washed (by means of old iron immersed in it, according to the German method) produces great quantities of fine copper, so that the proprietors have there obtained in one year near one hundred tons of the copper precipitated from this water.

5. If this water was afterwards evaporated, it would yield *green vitriol*, or *vitriolated iron*, at nearly the rate of two hundred tons of *vitriol* for each hundred ton of *iron* at least: which, at the rate of 3 *pounds sterling* per ton, might perhaps produce very good profit to the undertakers, if any should settle such a manufacture there. *The Editor from*
Bp. Warton.

substance,

substance, which in fact it greatly resembles.

It has not yet been found in large masses, but only in a superficial form, like a crust over other ores.

It is moderately hard and friable; of a fine *green* colour, and sometimes of a *bluish-green*, crystallised in a cubic form, or with a foliated texture, or in little scales, resembling *green mica*, or *talc*. This ore is easily dissolved by nitrous acid: the solution takes a green colour; and the metal may be precipitated on a polished plate of iron.

If some drops of a *nitrous solution* of *silver* be mixed with it, a white powder of *luna cornea* will be precipitated, which discovers the presence of the *muratic acid* in this ore.

Dr. Werner, in his German translation of the *Mineralogy* of our Author, describes this copper-ore: he sent a specimen of it to Professor Bergman, who analysed it, as he informs us in the Sect. 191. of his *Sciagraphia*, as well as when he speaks of the *minæ cupriferae* in his *docimasia humida*, p. 431.

Mongez mentions four fine samples of this ore, that were brought from the mines of Johnn Georgenstad; and adds, that a similar kind of copper-ore was sold so late as the year 1784 at Paris, by a person called Dans, as a mere *green mica*. The Editor.

S E C T. 331. (part of 200.)

5. *Copper-coal ore* [a].

This copper ore consists of the calces of this metal mixed with a bituminous earth. See Sect. 258 (161) pag. 501.

See Sect. 258. (161.) p. 501.

S E C T. 332. (Additional.)

Observations on Copper.

Copper-ores are found in almost all parts of the world; and are easily distinguished from those of any other metal, by the *blue colour* they give to *volatile alkali*, on being digested with it, after they have been previously *roasted*; otherwise it is possible that the *arsenic*, which they sometimes contain, and even the *sulphur*, if in sufficient quantity, may prevent this effect, when they are in their crude natural state; *viz.* before their being roasted by the action of fire.

[a] In the Banat of Temeswar, below the green copper-calx, they find a compact, blackish-brown substance, which is there called *pitch-ore*; it contains a considerable quantity of copper, and, when put into the fire, does not burn with a flame. We are still in want of an accurate enquiry into its constituent parts. *Brunsch.*

Copper mixt with black pitchy rock-oil has been found in Cornwall, according to Raspe's account. *The Editor.*

They

They are particularly found in Spain, France, England, Norway, and Transylvania. The copper that comes from Japan, according to Neumann, is much superior to any other that is found in Europe.

As to England in particular, no country in the world can boast of copper-mines more numerous, nor more productive for a longer period. It seems as if this Island was grounded on a metallic bottom, of various kinds, which will never be exhausted by all the labours of mankind for centuries to come [a].

The

[a] Besides the celebrated copper-mines at *Arklow*, in the County of *Wicklow*, in Ireland, there are no less than 17 out of the 48 counties of England, in which copper-mines are found; as mentioned by Dr. Campbell in the 2d vol. p. 44, of his *Political Survey of England*. These are Cardiganshire, Cheshire, Cornwall, Cumberland, Derbyshire, Devonshire, Lancashire, Isle of Man, Northumberland, Shropshire, Somersetshire, Staffordshire, Yorkshire, Wales, Warwickshire, Westmoreland, and North Britain: some that are worked at this time give such large products of this metal, that the opening more copper-mines in this island would probably affect the copper trade of Europe in a very considerable manner. The *Eton-mine*, in the Estate of the Duke of Devonshire, on the frontiers of Derbyshire, but properly situated in the county of Staffordshire, produces at least 300 tons of copper *per annum*. That of the mountain called *Paris*, in the Island of Anglesey, whose *bea of ore* is about 40 feet in thickness, produces about 1500 tons of copper in the year: and the copper-mines of Cornwall produce no less than 4000 tons in the same period. My late and much regretted friend, Mr. Jars, who visited these mines in the year of 1770, found, upon calculation, that the annual produce of these mines amounted to 140,000 pounds sterling: and M. H. Klaproth, in his *observations* on the fossils of Cornwall,

The uses of copper are very numerous, although not thoroughly known to every one. Its great ductility, lightness, strength, and durability, render it of a very extensive usefulness. Blocks, or bars of copper, are reduced into flat sheets of any thickness, by being first heated by the reverberation of the flame, in a low-vaulted furnace, properly constructed for the purpose; and then immediately applied between large rollers of steel, or rather of case-hardened iron, turned by a water-wheel or by the strength of horses; so that the hot metal is there quickly squeezed; and the operation is repeated, bringing the rollers every time nearer to one another, till the metallic sheet acquires the intended thickness.

These copper sheets are very advantageously employed in sheathing the bottoms of men of war, and other sea-vessels, which, by this means, are prevented from being attacked by the sea-worms, and are kept clean from various marine concretions, so as to sail with considerably greater swiftness. Copper sheets are also employed to cover the tops of buildings, instead of slates or earthen tiles, as is used in Sweden; and some Architects have begun to introduce the use of copper covering into Great Britain, which is much lighter, and may be

wall, just published (in 1787) asserts that this account is not an exaggerated one. See No. 3 and 4. of the note to Sect. 330. page 696.

used with great advantage, although it must be much dearer in the prime cost [b].

Sundry preparations of copper are employed in *painting*, *staining*, and for colouring glass and enamels [c].

But

[b] The following table was published by Bp. Watfon, in his Essay (page 326. of his 4th vol.) by which appears the respective weight of each of the 5 materials here mentioned, that is required for covering a surface of 42 yards square, viz.

Tile	54	} hundred weight.
Coarse slate	36	
Lead	27	
Fine slate	26	
Copper	4	

[c] The solution of copper in *aqua fortis* stains marble, and other stones, of a green colour: when precipitated with *chalk*, or *whiting*, it yields the *green* and the *blue verditer* of the painters.

According to Lewis, a solution of the same metal, in volatile spirits, stains ivory and bones: when macerated for some time in the liquor, they become of a fine *blue colour*, which, however, tarnishes by exposure to the air, and becomes green afterwards.

2. The same author prepared elegant *blue glasses*, by melting common glass, or powdered flint and fixed alkaline salt, with blue vitriol, and with an amalgam of copper: fine green ones were made with green verditer, and with blue verditer, as well as with the precipitate of copper, made by fixed alkalies, and with a precipitate by zinc; and a *reddish glass* was produced by the calx and scoria of copper made by fire alone. Even in this vitreous state, it seems as if a continuance of fire had the same effect in regard to colour, as air has upon copper in other forms: as some of the most beautiful *blue glasses*, by continued fusion, have changed to a *green colour*. Editor.

3. Verdeggris, called *ærugeo*, *æs viride*, and *viride æris*, in Latin, is a preparation of copper dissolved by the vegetable acids;

But the most common use of copper is, to make all sorts of *large stills, boilers, pots, furnels*, and other *various vessels*, employed by *distillers, dyers, chemists*, and various other ma-

acids; which act on this metal, dissolving it very slowly, but in considerable quantities. It produces a fine green pigment for painting, both in oil and in water colours, inclining more or less to the *blueish*, according to circumstances. This preparation is made in large quantities in France, particularly about Montpellier, by stratifying clean copper-plates with the husks of the grapes, that remain after the juice has been pressed out, to be turned into wine by a proper fermentation. The husks soon become acid, and corrode the copper-plates: their whole surface is covered, after a certain time, with a very beautiful green crust, which is the *verdegris*. This is nothing else but the copper corroded by the acid of tartar, analogous to the acid of vinegar, which abounds in the wines of Languedoc, and especially in the husks, and stones of grapes, which have a very austere taste. *Verdegris* is a very violent poison.

4. This rust of copper, *viz.* the *verdegris*, is not quite saturated, nor converted into a neutral salt, for it is soluble in water: nor does it crystallize till it is purified by a new solution in distilled vinegar; which is then called, though improperly, *distilled verdegris*, or *flowers of copper*. The cakes of verdegris for this operation must be chosen, neither moist nor unctuous, but dry, compact, and of an uniform texture, of a lively green colour throughout, and as free as possible, from white or black specks, and seeds, or stalks, of the grape. The Dutch, who prepare these crystals in a large quantity, after duly evaporating the solution, set it to shoot, not, as is customary in a cold, but in a warm place, as practised for making *sugar candy*. If these crystals be distilled, the most strong acetic acid is produced, called *Radical vinegar*. But if rectified spirits of wine, or some volatile alkalies, be added to that acetic solution of *verdegris*, small blue crystals will be immediately formed, called *antipileptic crystals of copper*, as Newmann asserts. *The Editor chiefly from Newman and Lewis.*

manufacturers,

nufacturers, who make use of large quantities of hot liquors in their various operations.

Unhappily, the good qualities of copper, and chiefly its ductility and great durability, induced our ancestors to employ it likewise, without due consideration, in all kinds of kitchen vessels, as *boilers, porridge-pots, kettles, sauce-pans, &c.* as they were not aware of the poisonous qualities of this metal, whenever its solution [*d*],
even

[*d*] Copper dissolves not only in *every acid*, but in *alkalies* also, both *fixed* and *volatile*, in *neutral* saline-liquors, and in *oils*: when dissolved, it exhibits fine *blue, green, or bluish* colours, by which this metal is readily distinguished, however mixed or disguised with other substances. Even pure water, suffered to stand long in copper vessels, extracts so much as to gain a coppery unwholesome taste: and it is remarkable, that fluid liquors become more impregnated with this taste on standing in the cask, than if boiled in the vessel for an equal time. The confectioners prepare acid syrups, even those of orange and lemon-juice, by boiling them in clean copper vessels, without the preparation's receiving the ill taste of the metal; whereas either the juices by themselves, or the syrups made from them, and, what is still worse, the fricassees and other culinary ragouts, if kept cold in clean copper vessels, soon become impregnated with a metallic taste, and acquire the poisonous qualities of the copper.

2. Many have deceived the public, by affirming, that copper vessels, if well tinned in the inside, cannot communicate any poisonous quality to the aliments cooked therein. But, as Gellert observes (pag. 262. of his *Metallurgic Chymistry*), it is by no means sufficient; because there will either some small imperceptible parts remain uncovered with the tinning powder; or such minute parts will be rubbed off in time by the use and cleaning of the vessel, which being then exposed to the effect of the acting liquors, will produce the same danger, by generating the poisonous verdigris, and dissolving the surface of the copper.

3. Even,

even in the slightest quantity, is once taken internally with any sort of food, or otherwise.

Examples are too frequent of the fatal consequences, from eatables that had received a taint from *copper* vessels, and even from *silver* ones that were largely alloyed with *copper*; whether on account of the acid nature of the food itself, which dissolves and corrodes the surface of the metal it touches; or from the vessel having contracted the copperish-green rust, called *verdigris*, by laying exposed to the air; a poison, which is so readily formed as to baffle the common attention of the scullions and cooks. I saw at Paris the melancholy spectacle of a middle-aged man, of a stout bodily complexion, but who laboured

3. Even if the danger from the copper could safely be prevented, it is well known, that instead of employing pure tin, which is not reckoned an unwholesome metal, the mixture generally used for tinning copper, or brass vessels, consists of 3 parts of lead and 5 of pewter, or at best of 10 of lead with 16 of tin: and it has been already mentioned (Sect. 304. Note [b]. N° 4. and N° 14 of the Note [a] to p. 670), that a solution of lead taken internally with our food, or in any other way, is likewise highly pernicious to the life of animals.

4. Instead of that mixture of tin with lead, zinc alone may be advantageously employed to cover the inside of copper or brass-vessels, as hath been proposed and executed at *Rouen* in France; and perhaps in other manufactures of this kind (as Watson relates, p. 177 of the 4th vol. of his *Essays*.) In this case the last objection, from the unwholesomeness of the lead, would be obviated; but at any rate there remains still the danger arising from the wearing off the zinc in some parts of the internal surface of the vessels: and consequently no copper, nor brass-vessels of any sort, should ever be employed for culinary purposes. *The Editor.*

under

under a paralytical disorder, and was deprived of the use both of his limbs and of his intellectual powers, during the last four, or more years of his lingering life: his disorder was produced by eating a fricassée, that remained the preceding night in the stewing copper-pan in which it had been dressed. Application had been made to the best physicians, but they were unable to give him the least relief from so melancholy a situation [e].

Although

[e] 1. Hardly a year passes without hearing of whole families, and numerous guests, that have been destroyed by this kind of poison of copper, or its green-rust, which happened to be dissolved in the soups and stews of their meals; and, if death do not ensue, as in the case mentioned in the text, it is certain at least, that great part of the chronical diseases, palsies, gripings in the bowels, and other habitual complaints, which are supposed to proceed from other causes, do originate from the pernicious old and vulgar custom of employing this poisonous metal in our kitchens, on account of the œconomy supposed to arise from its durability and neat appearance. To my own knowledge, the late Marquis de Courtanvaux, and a few others were taught at last from their own danger not to allow the least vessel of copper or brass, in their kitchens, instead of which they substituted those of *plated, forged, and cast-iron*, properly tinned in the inside.

2. In consequence of some representations from the *College of health*, the use of *copper vessels*, in the fleets and armies of *Sweden*, was abolished in the year 1754; and *tinned iron* (though it would be still better, if *tinned with zinc*) was ordered to be substituted in their stead, as appears by the *Memoires* of the Prussian Academy, quoted by Dr. Watson, page 150 of the 4th vol. of his *Essays*. It is indeed a general opinion, of the best physicians of the age, that many of the violent and obstinate diseases of the European armies, and of the crews of men of war, and other large ships, intirely proceed from the use of greasy and dirty *copper*, or *brass vessels*, employed in the cooking of their messes.

Z z

Neumana

Although copper, when pure [f], is extremely valuable on account of its ductility, lightness,

3. Neumann knew a person, who having accidentally swallowed a brass-sleeve button, was seized with the most violent symptoms, and died in misery; no medicines giving any effectual relief; and he also knew various instances of vehement vomitings and convulsions, which proceeded from the *unguentum ægyptiacum*, whose basis is *verdigris*, applied to ulcers in the mouth. See the first vol. of his works in 8vo. pag. 98. The Editor.

[f] 1. It is well known that the impurity of copper proceeds from the mixture of heterogeneous substances that are alloyed with it, on account of being naturally contained in the copper-ores. Iron and arsenic are the chief of these natural mixtures. The copper ores of *variegated* colours, the *white*-copper ores, and generally those mineralized by sulphur, contain a greater proportion of iron: whilst the *blue* and *green* copper ores commonly produce a purer metal, being free, for the most part, of any considerable ferrugineous mixture.

2. The great aim, therefore, of the metallurgist must be directed to separate these mixtures from the copper, beginning by the proper examination of the ore, and by ascertaining the proportion of sulphur that may be required to scorify the quantity of iron there contained. The ore should always be roasted by a slow fire, in a close furnace, which contributes the best towards scorifying the ferrugineous and heterogeneous mixtures; and the same operation must be repeated after the second and third fusion of the metal, till its grain becomes of an homogeneous fine texture. The mixture of sulphureous pyrites in the fusion of the metal contributes towards obtaining this object; if their quality be chosen, according to the quantity of sulphur wanting.

3. But in the second, third, and following operations, only pure sulphur should be added, to scorify the remainder of the iron, that is still intermixed with the copper. This should be done when the metal is already well fused; covering it immediately with a proper quantity of charcoal, and separating the scoria or dross formed on the surface of the fused metal.

The

lightness, and strength; it is, however, less useful, on many occasions, from the difficulty of forming large masses of work; as it is not an easy matter to cast copper solid, so as to retain all its properties entire. For if the heat be not sufficiently great, the metal proves deficient in toughness when cold; and if the heat be raised too high, or continued for a length of time, the copper blisters on the surface, when cast in the moulds: so that the limits of its fusion are very contracted. And from these circumstances, pure copper is rendered less applicable to several purposes.

We find, however, that the addition of a certain proportion of zinc removes almost all these inconveniences, and furnishes a mixed metal more fusible than copper, very ductile and tenacious when cold, which does not so readily scorify in a moderate heat, and which is less apt to rust from the action of air and moisture.

Copper is the basis of sundry compound metals for a great number of mechanical and æconomical uses of life, such as *brass* [g],
princes-

4. The copper extracted from those mines near Newfol, in Upper Hungary, is said to be usually melted 14 times, before it is fit for use. These are the greatest copper-mines in all Hungary. There are, however, other mines, whose copper requires far less fusions to be well purified.

5. The above was the process of Mr. Delius, director of the mines of Bannat near Temesware, in Hungary, proposed by him to the Imperial Board of the Austrian Mines. See *Journal de Physique* for July 1780.

[g] 1. *Brass* is frequently made by cementing plates of copper with *calamine*, where the copper imbibes one-fourth

princes-metal, tombac, bell-metal, white-copper, &c.

If the mixture is made of four to six parts of copper, with *one* part of zinc, it is called *Prince's-metal*. If more of the copper is taken, the mixture will be of a deeper *yellow*, and then goes by the name of *Tombac*, or *Tompac*, as Gellert calls it (p. 359. of his *Metallurgic Chemistry*, edit. of 1776.); so that even copper by itself has got that name, says he, when its surface is only stained, by the fumes of zinc, with a gold-yellow colour, which is done, by mixing flowers of zinc with charcoal-dust, throwing this mixture into a heated muffle, and immediately holding a piece of red-hot copper in the fumes rising from the zinc.

Bell-metal is composed of copper and tin. When this last amounts to one-third of the mass, it becomes of a very beautiful yellowish-white.

It

or one fifth its weight of the zinc which rises from the calamine. The process consists in mixing three parts of calamine and two of copper with charcoal dust in a crucible, which is exposed to a red heat for some hours, and then brought to fusion. The vapours of the calamine penetrate the heated plates of copper, and add thereby to its fusibility. It is of great consequence, for the success of this process, to have the copper cut into small pieces, and intimately blended with the calamine.

2. In most foreign foundries the copper is broken small by mechanical means, with a great deal of labour; but at Bristol the workmen employ an easier method. A pit is dug in the ground of the manufacture, about 4 feet deep, the sides of which are lined with wood. The bottom is made of copper

It is remarkable that zinc, which is scarcely malleable, on being united with copper, produces malleable brass; whilst bell-metal is composed of malleable tin, and is so brittle, that it may be reduced to powder.

The specific gravity of bell-metal is likewise singular; for if the tin is about one-third of the mass, it is heavier than the brass itself; whilst, in other doses, it is only as heavy as the copper. Bell-metal is extremely hard and sonorous, and is less subject to alterations by exposure to the air, than any other cheap metal. On this account it is advantageously employed in the fabrication of various utensils and articles, as *canons, bells, statues, &c.* in the composition of which, however, other metals are mixed in various proportions, according to the fancy and experience of the artist.

White-

per or brass: and is moveable by means of a chain. The top is made also of brass with a space near the centre, perforated with small holes, which are luted with clay: through them the melted copper is poured, which runs in a number of streams into the water, and this is perpetually renewed by a fresh stream, that passes through the pit. As the copper falls down it forms itself into grains, which collect at the bottom. But great precaution is required to hinder the dangerous explosions, which melted copper produces, when thrown into cold water, which end is obtained by pouring small quantities of the metal at once. The granulated copper is completely mixed with the powdered calamine, and fused afterwards. The process lasts 8 or 10 hours, and even some days, according to the quality of the calamine.

3. It is a wonderful thing, says Cramer, that zinc itself, being simply melted with copper, robs it of all its mal-

Z z 3

leability;

White-copper is prepared with arsenic. Neumann prescribes, to mix equal parts of arsenic and nitre, pulverized and mixed together, which being injected into a red-hot crucible, are to be kept in a moderate fire, till they subside and flow like fused wax. One part of this mixture is to be injected into four parts of melted copper; and the metal, as soon as it appears thoroughly united together, is to be immediately poured out. The copper is thus whitened; and if melted with a considerable part of silver, is so much improved, that vases, candlesticks, and various other pieces being made with it, hardly can be distinguished from true silver. The *white-copper* that is imported from China and Japan, seems to be nothing else than a mixture of *copper* and *arsenic*, since Geoffroy asserts that, by repeated fusions, arsenical fumes were exhaled from it; and at last the red copper was all that remained, having lost with its

leability; but if it be applied in form of vapour from the calamine, the sublimate, or the flowers, it does not cause the metal to become brittle.

4. The method mentioned by Cramer to make brass from copper, by the volatile emanations of zinc, seems to be preferable to to any other process, as the metal is then preserved from the heterogenous parts contained in the zinc itself, or in its ore. It consists in mixing the calamine and charcoal with moistened clay, and raming the mixture to the bottom of the melting pot, on which the copper, mixed also with charcoal, is to be placed above the rammed matter. When the proper degree of heat is applied, the metallic vapour of the zinc, contained in the calamine, will transpire through the clay, and attach itself

its whiteness one-seventh part of its former weight, as Lewis relates.

But the attention of the philosopher is more particularly directed to that kind of *white-copper* with which speculums of reflecting telescopes are made [b]. *The Editor.*

S E C T.

self to the copper, leaving the iron and the lead, which were in the calamine, retained in the clay, without mixing with the upper metal. Dr. Watson says, that a very good metallurgist, of Bristol, named John Champion, has lately obtained a patent for making brass, by combining zinc in the vaporous form, with heated copper plates; and that the brass from this manufacture is reported to be of the finest kind; but he knows not whether the method there employed is the same here mentioned from Cramer.

5. Brass is sometimes made in another way, by mixing the two metals directly: but the heat requisite to melt the copper, makes the zinc burn and flame out, by which the copper is defrauded of the due proportion of zinc. If the copper be melted separately, and the melted zinc poured into it, a considerable and dangerous explosion ensues; but if the zinc is only heated and plunged into the copper, it is quickly imbibed, and retained. The union, however, of these two metals succeeds better, if the flux, composed of inflammable substances, be first fused in the crucible, and the copper and zinc be poured into it: as soon as they appear thoroughly melted, they are to be well stirred, and expeditiously poured out; or else the zinc will be inflamed, and leave the red copper behind.

6. Neumann says, that 64 pounds of copper imbibe 26 pounds from the calamine, and yield 90 pounds of brass. In general, all the yellow compounds are nothing else but the same two substances in different doses. When the zinc enters in a greater quantity into the brass, the colour of the compounds becomes more and more pale. The quantity of zinc in good brass may be about one third of the weight. *The Editor chiefly from Cramer.*

[b] 1. The best proportions to make this kind of *white-copper*, are 32 parts of fine *red copper*, one part of brass; one
Z z 4 part

part also of *silver*; 15 parts of *tin* (of the best sort called *Grain-tin*); and about 3 parts of *white-arsenic*. The process given by the late J. Edwards, who was rewarded by the *Board of Longitude*, for disclosing it to the public, was published in the *Nautical Almanack* for 1787; and is as follows: Melt the copper in a large crucible, employing some *black flux*, composed of 2 parts of *tartar*, and one of *nitre*; when melted, add to it the *brass* and the *silver*. Let the *pure tin* be melted in another crucible, also with some *black flux*. Take them both from the fire, and pour the melted *tin* into the fused mass in the large crucible. Stir the whole well with a dry spatula of *birch*, and pour off the fused metal immediately into a large quantity of cold water. The sudden chill of the water will cause the fluid metal to divide into an infinite number of small particles, which will cool instantly.

2. If the copper be completely saturated, the fracture of one piece of this mixed metal will appear *bright*, and of a *glossy look*, resembling the face of *pure quicksilver*. But if it is of a *brown-reddish colour*, it wants a little more *tin*. To ascertain the required proportion, melt a small quantity, known by weight, of the mixed metal, with a known very small part of tin; and, if necessary, repeat the trial with different doses, till the fracture of the new mixture looks as already described. Now having ascertained the necessary addition of *tin* that is required, proceed to the last melting of the whole metal, together with the additional proportional dose of tin; fuse the whole, observing the same cautions as before; and you will find that the mixture will melt with a much less heat than that for the first fusion. Have ready as many ounces of white arsenic in coarse powder as there are pounds in the weight of the metal; wrap up the *arsenic* in a small paper, and put it, with a pair of tongs, into the crucible; give it a good stir with the spatula, retaining the breath to avoid the arsenical fumes or vapours (which however are not found to be hurtful to the lungs) till they disappear; take the crucible off the fire, clear away the dross from the top of the metal, pour in about one ounce of powdered *rosin* with as much *nitre*, in order to give the metal a clean surface and pour out the metal into the moulded flasks.

3. The *speculum* should be moulded with the concave surface downwards, and many small holes should be made through

S E C T. 333. (201.)

Iron. *Ferrum*, Mars, Lat. *jern*, Swed.
Eisen, Germ. *Fer*. French.

General Properties of Iron. [a].

This metal is

a. Of a blackish blue shining colour.

It

through the sand upwards, to discharge the air. The moulding sand from *Highbate* near London, used by the founders, is as good as any, for casting these metallic mirrors.

N. B. The cast metal should be taken out from the sand of the flasks, whilst it is hot; or else it may happen to crack, if let to cool within. *The Editor.*

[a] 1. Iron is the most diffused and the more abundant of all metallic substances; since it is not only found either intermixed with, or united to, all the *fossil bodies* of the earth; but also, in combination with the productions of the two other kingdoms of nature, the *vegetable* and the *animal bodies*, whose juices and blood are coloured by it; and there is even a probability that these organic substances have the power of producing this metal by themselves; for it is known that it may be extracted even from the ashes of those plants that had been raised in pure water. Iron is contained in almost all the coloured stones, even in the hardest and most brilliant gems, in the bitumens, moulds, and waters, and in the greatest number of metallic ores.

2. This metal in its reguline state is of a more or less *dark-blue* colour in various specimens. It may receive such a polish as to appear *white*; and, after being hardened, it may be polished so highly as to shine with an amazing brilliancy. However, it soon tarnishes, if exposed to the action of the atmosphere, and to moist air in particular; taking a *rusty*

- b.* It becomes ductile by repeated heating between coals, and hammering.
- c.* It is attracted by the loadstone, which is an iron ore; and the metal itself may also be rendered magnetical.
- d.* Its specific gravity to water is as 7,645, or 8000 : 1000.

It

dusky blackish hue, and contracting a yellowish and reddish rust on its surface. Nevertheless, it has been observed that hard iron, or steel, well polished, has sometimes escaped being attacked by rust, under running water.

3. Iron has a particular and very sensible smell, when strongly rubbed, or heated. It produces a styptic taste, which it communicates to the water in which it is extinguished after ignition.

4. Its tenacity, ductility, and malleability, are very great. It exceeds every other metal in elasticity and hardness, when properly tempered. An iron wire of *one-tenth* of an inch thick, is able to support 450 pounds weight, without breaking, as Wallerius asserts.

5. Iron extends difficultly under the hammer, but it may be extended to a great degree, and drawn into wire as slender as the finest hairs. It is more easily malleable when ignited than when cold; whereas other metals, though ductile when cold, become quite brittle by heat.

6. It grows red-hot sooner than other metals: nevertheless, it melts the more difficultly of all, platina and manganese excepted. Exposed to a white heat, less than sufficient for its fusion, it contracts a semivitreous coat, which bursts at times, and flies off in sparkles. It does not tinge the flame of burning matters into bluish or greenish colours, like other imperfect metals, but brightens and whitens it; hence the filings of iron are used in compositions of fire-works, to produce what is called *white-fire*.

7. When strongly heated, it appears covered on its surface, with a soft vitreous matter like varnish; in this state pieces of iron may be made to cohere to one another, by being hammered together; this is called the *welding* of iron; the joint unites so well as not to be discovered afterwards, if properly made.

- e. It calcines easily to a black scaly calx, which, when pounded, is of a deep red colour.
- f. When this calx is melted in great quantity with glass compositions, it gives a blackish brown colour to the glass; but in a small quantity a greenish colour, which at last vanishes,

made. This property of *welding* is not found in the other metals.

8. *Iron*, or rather *steel*, expands the least of all hard metals by the action of heat; but *brass* expands the most; and on this account these two metals are employed in the construction of *compound pendulums* for the best sort of regulating clocks, for astronomical purposes. Each of these pendulums consist of 5 rods of steel, and 4 of brass; and, on account of their appearance, are called *grid-iron pendulums*. These 9 rods are placed in an alternate order, the middle rod being of steel, and suspending the lenticular ball. They are so connected with each other at their ends, that while the expansion of the steel rods has a tendency to depress the center of oscillation, the expansion of brass-rods acting upwards, tends to raise it; and, being duly proportioned, their expansions balance and correct each other, preserving the pendulum of the same length in any different temperature of the atmosphere.

The late ingenious John Harrison was the inventor of this useful contrivance about the year 1725 or 26; and it is rather singular, that the laborious Musschenbroek attributes this invention to G. Graham, in the article 674 of his *Introduction to Natural Philosophy*, only because the first pendulum he heard of this kind, had been made by this last excellent artist.—Mons. De la Lande, however, has done justice to the real inventor, in the article 2462 of his *Astronomy*, where he describes this construction; and its great advantages for the regularity of the going of astronomical regulators.

9. It appears, however, from the experiments of Mr. Smeaton in the *Philos. Transact.* for 1750, that zinc suffers still a greater expansion from the same quantity of heat, than

vanishes, if urged by a strong degree of heat.

- g. It is dissolved by all salts, by water, and likewise by their vapours. The calx of iron is dissolved by the spirit of sea-salt, and by aqua regia,

The

any other metal. Consequently fewer rods of steel and zinc may produce the same effect when properly combined. Only 3 rods of steel, and two of zinc, mixed with some silver, produce, in our best English regulators, the very same effect which formerly required almost double the number of these metallic rods. The following table of the expansions of different metals, observed by Mr. Smeaton, with his new Pyrometer, is extracted from the XLVIIIth vol. of the Phil. Transact. p. 612.

13. *Table shewing what is the expansion of a foot of the following metallic substances, by the temperature of 180 degr. of Fahrenheit's thermometer, viz. from the freezing point to that of boiling water, expressed in 10,000 parts of the English inch.*

White glass barometer tube 100	Spelter solder, viz.	
Martial Regulus of antimony 130	brass 2. zinc 1.	242
Blistered steel 138	Fine pewter	274
Hard steel 147	Grain tin	298
Iron 151	Soft solder, viz. lead 2.	
Bismuth 167	tin 1.	301
Hammered copper 204	Zinc 8. tin 1. a little	
3 parts of copper with 1 of tin 218	hammered,	323
Cast brass 225	Lead	344
16 parts of brass with 1 of tin 229	Zinc or spelter	353
Brass-wire 232	Zinc hammered an inch	
Speculum metal 232	per foot.	373

11. Iron, in the act of fusion, instead of continuing to expand, like the other metals, shrinks, as Dr. Lewis observes; and thus becomes so much more dense, as to throw up such part, as is unmelted, to the surface; whilst pieces of gold, silver, copper, lead, and tin, put in the respective metals in fusion, sink quickly to the bottom. But in its return

- b.* The calx of the dissolved metal proves yellow, or yellowish brown; and in a certain degree of heat, it turns red.
- i.* The same calx, when precipitated from acids, by means of the fixed alkali, is of a greenish colour; but it becomes blue, when precipitated

turn to a consistent state, instead of shrinking, like the other metals, it expands; sensibly rising in the vessel, and assuming a convex surface, whilst the others subside, and appear concave. This property of iron was first taken notice of, by Reaumur, and excellently fits it for receiving impressions from the moulds into which it is cast; being forced into their minutest cavities. Even when poured thick into the mould; it takes, nevertheless, a perfect impression; and it is observed, that cast iron is somewhat larger than the dimension of the mould; whilst cast figures of other metals are generally smaller.

12. The *vitriolic acid* dissolves iron readily, and forms the *green vitriol* of Sect. 207. This salt, in actual solution, is deprived of phlogiston by the contact of air, and the attraction between the acid and the metallic particles is diminished; a quantity of ochreous matter, or ferruginous calx, therefore, falls to the bottom in this case, and the liquor, as well as the crystals, obtained by evaporation, are paler.

13. This acid, the vitriolic, requires to be diluted with 304 times its quantity of water, to enable it effectually to dissolve iron; and, during the dissolution, a strong aerial fluid arises, called *inflammable air*, which, on being mixed with atmospheric air, takes fire at the approach of the flame of a candle. A glass phial, of about two ounces measure, with one-third of *inflammable air*, and the rest of *common-air*, produces a very loud report, if opened in the same circumstance; and if it be filled with two-thirds of *inflammable air*, mixed with one of *dephlogisticated air*, the report will be as loud as the explosion of a pistol with gun powder. It is highly probable, and even demonstrated, that inflammable air is the true *phlogiston*, whose real existence some modern philosophers endeavour to overthrow. See note a to page 441: and Priestley's ad vol. on *different kinds of air*, pag. 98 and 99.

Dilute

tated by means of an alkali united with phlogiston, in which last circumstance the phlogiston unites with the iron. These two precipitates lose their colour in the fire, and turn brown.

The

15. Dilute *nitrous acid* dissolves iron, but this saline combination is incapable of crystallizing. Strong *nitrous acid* corrodes and dephlogisticates a considerable quantity of iron, which falls to the bottom.

Marine acid likewise dissolves iron, and this solution is also incrySTALLIZABLE.

16. The *Prussian acid* precipitates iron from its solutions, in the form of *Prussian blue*.

N. B. An account of this acid will be given in the *Article of Assaying by the Humid way*.

17. This metal is likewise sensibly acted upon by alkaline and neutral liquors, and corroded even by those which have no perceptible saline impregnation; the oils themselves, with which iron utensils are usually rubbed to prevent their rusting, often promote this effect in some measure, unless the oils had been previously boiled with litharge, or calces of lead.

18. Galls, and other astringent vegetables, precipitate iron from its solutions, of a deep *blue* or *purple colour*, of so intense a shade as to appear *black*.

It is owing to this property of iron, that the common writing ink is made by the process described in the Note N° 9 to p. 405; although the doses and circumstances may be changed in different ways without affecting the success.

The infusion of galls, and also the Prussian alkali, are tests of the presence of iron, by the colours they produce on any fluid. Acids, however, dissolve the coloured precipitates by the former; and from hence arises that the marine acid is successfully applied to take off ink-spots, and iron stains from white linens. Alkalis, however, convert these iron-precipitates into a brown ochre.

20. Iron has a strong affinity with sulphur. If a bar of iron be strongly ignited, and a roll of brimstone be applied to

- k. The vitriol of iron is green.
 l. It is the most common metal in nature, and at the same time the most useful in common life; notwithstanding which, its qualities are perhaps very little known.

S E C T.

to the heated end, it will combine with the iron, and form a fusible mass, which will drop down. A vessel of water ought to be placed beneath, for the purpose of receiving and extinguishing it, as the fumes would otherwise be very inconvenient to the operator.

21. A mixture of iron-filings and sulphur in powder, moistened with water, and pressed so as to form a paste, will in a few hours swell, become hot, fume, and even burst into a flame, if the quantity is large. The residuum furnishes martial vitriol. This process is similar to the decomposition of martial pyrites, from which some philosophers account for hot spring waters, and subterraneous fires. The mixture of water in this paste seems to be necessary to enable the vitriolic acid of the sulphur to act on the iron.

22. Iron is dissolved by all metals, made fluid by a sufficient heat, except lead, on which it floats distinct as oil upon water. Gold, of all metals, acts on it the most powerfully; though, as Cramer observes, if the iron contains any sulphur, it can scarcely be made to unite at all with gold.

23. It refuses likewise to unite to mercury; and no method has hitherto been discovered to amalgamate these two substances together, though in some circumstances a mutual cohesion has been observed to take place, as was noted at p. 580. N° 3.

24. Among the semi-metals, zinc is the most difficultly combined with iron; not from a natural indisposition to unite, but from the zinc being difficultly able to sustain the due degree of heat. This mixture is hard, somewhat malleable, and of a white colour, approaching to that of silver.

25. *Regulus of Antimony*, as soon as it melts, begins to act on iron, and dissolves a great quantity of it. If this regulus, when fused, be stirred with an iron rod, the end of it will be soon

S E C T. 334. (Additional.)

Native Iron.

It is now known that *native iron* exists in many places. The most remarkable mass of this sort is that discovered in Siberia, which weighed 1600 pounds. It is of that species called *Red short*, being *malleable* while cold, but *brittle* when red-hot. *Kirwan*.

It can hardly be doubted, but that this great mass of iron, brought by Pallas from Siberia into Europe, is the produce of nature. Its composition resembles that of forged iron; for a centenary (= 63 *grains*) yields, by means of the muriatic acid, 49 cubic inches of inflammable air; and from many experiments it is found that ductile iron yields from 48 to 51 of the same inches. *Bergm. Sciagraph*.

Margraaf found some of this kind of iron, in the form of ridges, at Ebenstock (or Eybenstock) in Saxony. *Fourcroy*.

Native iron has been found in a *cubical form*, at Senegal in Africa, out of which the black inhabitants make various vessels for

soon melted. According to Cramer, iron mixed with *Antimony*, is not attracted by the Magnet.

Arsenic likewise unites easily with iron, and discovers a great attraction to it, forsaking all the other metals to combine with this. It renders the iron white, very hard, and brittle.

The Editor chiefly from Newman, Lewis, Fourcroy, Nicholson, &c.

their

their own use; also at Eibenstock, on the Margravate of Misnia, in the Upper Saxony, and at Stiria on the Circle of Austria. Some native irons have been found in a polyédrical granulated form, and of a bright yellow colour, which on being polished shew their proper metallic colour; these two species of native iron are mentioned by Wallerius, in his Spec. 321 [a].

Monet, quoted by Mongez, mentions a piece of many pounds weight, that has all the qualities of a good iron, and is kept in the Collection of the College of the Mines at Freyberg. Other specimens have been found also of the kind near Bareith, which were malleable: and lastly, the same Mongez mentions three specimens of *native iron*, kept in the King's cabinet in the *Royal Garden* at Paris; one of which was found at Kaumtsdorf in Thuringia; this is surrounded by an ore of the hepatic iron, and has a cavity with some protuberances of a brown hæmatites. The other

[a] Wallerius makes no difficulty in admitting that *native iron* has been found, without any preceding operation of art; and even answers to the objection stated by Lehman, who says, that perhaps the specimens of *native iron* might be produced by volcanic fires; by observing that the presence of proper fluxes cannot be supposed to exist in the volcanic craters. But I must acknowledge, that after having examined and considered with proper attention the specimen of *native iron* from Siberia, mentioned in the next *Note*, I cannot account for its formation in any other way than by its being a real volcanic production. *The Editor.*

two are from the *native iron*, found by Pallas on the Emir Mountains of Siberia [b].

S E C T. 335. (202.)

Calciform Iron.

Iron is found in a calciform state [a].

Hr

[b] I was favoured with a specimen of this native iron from Siberia, by the generous friendship of Dr. Matthew Guthrie, resident at St. Petersburg, who described it to me by the following words, in his letter of the 9th of Sept. 1777. "N^o 3d is a piece of the curious mass of native iron, discovered by my friend Pallas, on a mountain in Siberia, and is the first instance of this metal being found in this very pure malleable state. The pores of it were filled with a yellow vitreous matter, so hard as to cut glass, of which I also send a little in a paper apart, as it fell out on cutting specimens from the large mass. I am very sorry that the specimen of iron is so small, but it is a very good one, as it shows not only the cellular texture of the mass, but the varnish which Pallas speaks of, as lining its hollows; and is exactly in small, what the mass is in large." On my receiving this curious and wonderful specimen, I found that every circumstance corresponded exactly to the description given by the Doctor. The little cells were like spherical cavities; the varnish still adhering to some parts, appeared to be the contiguous crust of the glassy substance that was within; and the metallic mass was perfectly malleable, and rather softer than common iron. I made a present of this curious sample to my late worthy friend, the celebrated Dr. Fothergill, from whose hands it probably has passed to some other cabinet; since I was told, it was not found in his own, after his decease. See *Journal de Physique, Supplement, tom. 13. for 1778, p. 128.* The Editor.

[a] The basis of the calciform iron-ores, is either the *black* or *blackish brown* calx of iron, which is in some measure phlogificated and magnetic; or the *red* calx of iron, which

A. In form of calx, *Minera ferri calciformis pura*.

1. Pure.

a. Loose and friable, *Minera ferri calciformis pura friabilis*. Martial ochre, *Minera ochracea*.

1. Powdery, *Ochra ferri*, is commonly yellow or red: and is iron which has been dissolved by the vitriolic acid [*b*].

2. Concreted. Bog-ore.

a. In form of round porous balls.

b. More solid balls.

c. In small flat pieces, like cakes, or pieces of money.

is more dephlogisticated, and not magnetic before torrefaction. *Kirwan*.

Among all iron ores, the most numerous are the calciform; and seem to be of a secondary formation, *viz.* they are formed by the deposition and precipitation from waters, as appears by their mixture with various heterogeneous substances, many of which have belonged to organised bodies: they may be, therefore, looked upon as resulting from the decomposition of other iron-ores, made by water and the aerial acid, with which the moisture that circulates through the earth is always impregnated. For this general acid attracts the phlogiston contained in the true metallic ores, and in the martial æthiops it meets with; and this by a gradual and constant action, which is so much the more efficacious, as its power never ceases its exertion during the existence of the metallic compound, until the whole is reduced into a calciform state, or a martial *crscus*. According to Mongez, these calciform iron-ores may be properly divided into 1. the *ochreous* contained in this section: 2. the *crystallized*: 3. the *hæmatites*; and 4. the *swampy*, which will be treated of in the following notes. *The Editor, from Mongez.*

[*b*] See Note *g* to Section 340, where the *argillaceous* and the *big, or swampy* iron-ores, are described. *The Editor.*

d. In small grains.

e. In lumps of an indeterminate figure.

All these are of a blackish brown, or a light brown colour. They are found in lakes in the province of Smoland; and in marshes at Fiellryggen, between the chain of rocks which separates Sweden from Norway.

S E C T. 336. (203.)

Indurated, pure, Calciform Iron-ores.

b. Indurated, *Minera ferri calciformis pura indurata*. The blood-stone, *Hæmatites* [a].

Of

[a] The name of *hæmatites*, or *blood-stones*, is not given to these ores on account of their external colour, for they are also *blue*, *yellow*, *brown*, and *micaceous*; but because on being reduced to powder, or rubbed hard, they produce a *red*, or *blood* colour. The yellow hæmatites, however, of Sect. 339, only give the *yellow* colour, when powdered.

They seem to be the result of the primitive iron-ores; and to have been formed like the stony concretions, and the earthy stalactites. They are fibrous, and striated, like wood: some are formed in concentric layers, in oblong sticks, or small rods, in diverging radiations, and forming incrustations to other extraneous bodies; generally they are of a hard consistence; and some so much as to strike fire on being struck with hard-steel. The blackish hæmatites of Sect. 337. have a glassy shining fracture. The red ones of Sect. 338. to which the name of hæmatites more properly belongs, have sometimes a colour approaching to the *purple*: when they have some calcareous mixture in their substance, as often happens, they make effervescence with acids. But in general they contain some little *argill*, and *manganese*. The hæmatitic

1.. Of an iron colour, *Hæmatites cærulescens*.

This is of a blueish-grey colour ; it is not attracted by the load-stone, yields a red powder when rubbed, and is hard.

a. Solid, and of a dim appearance when broken.

b. Cubical, and of a shining appearance when broken.

c. Fibrous (*Sädig.*), is the most common *Torrsfen* of Sweden.

d. Scaly (iron glimmer), the *Eisenram* of the Germans.

This is for the most part as if it were testaceous, though the scales go across the strata of the stone. It is found at Jobibo, at Norrberne in Dalarne, and Reka Klitt, in the province of Helsingland.

1. Black, from Gellebeck, in Norway.

2. Blueish-grey, from Reka Klitt.

When this is found together with marcasite, as at Sandfwar in Norway, it is not

tical ores are not magnetic before torrefaction ; but they become black, and magnetic, by fire.

These ores are productive of very good iron ; and are found in great abundance in the province of Galiza, in the kingdom of Spain. The inhabitants of Compostelle, which is the capital town, make a good commerce of those hæmatites of the hardest kind, for the burnishing gold leaves, and various metals, therewith. Those I have seen employed to these uses were of the dark-blue kind, somewhat similar to black-lead. But there are many other parts in Europe, where these ores are plentifully found ; and in some places they form whole mountains : they afford from 40 to 80 per cent. of metal. *The Editor, chiefly from Kirwan, Mongez, and Bomare.*

only attracted by the loadstone ; but is of itself really a loadstone. Sect. 343.

c. Crystallised [b].

1. In octoédrical crystals,
2. In polyédrical crystals,
3. In a cellular form, from Mofsgrufvan, at Norberg in Westmanland.

These varieties are the most common in Sweden, and are very seldom blended with marcasite, or any other heterogeneous substance, except their different beds.

[b] The most extraordinary iron ores of this kind, both on account of their forms, and of their various and brilliant colours, are found in the island of Elba, near the coast of Tuscany. The crystallized ores are the most common, the purest, and the most beautiful ; and no where else similar specimens have been found. They exhibit various gradations of the finest colours, as *red, violet, blue, green, yellow, brown, black* ; and look, according to Coudrai's expression, like so many clusters of precious *emeralds, sapphires, diamonds, rubies, and topazes*. I beheld, indeed, with astonishment, some of these specimens, for the first time, on a mantle shelf of a private house at *Porto Longone*, where I touched on my sailing to Italy, at the end of 1755, soon after the earthquake of Lisbon ; and have seen ever since many specimens of the kind in various collections ; but they lose great part of their brilliancy on being exposed to the moisture of the atmosphere. These ores have no other mineralizer, but the *aerial acid*, as F. Pini and Mongez assert, against the opinion of Coudrai, who pretends that they contain Sulphur. Besides these crystallized ores, there are in the mines of Elba, various other iron-ores, such as of the *hematite kind*, the *ochreous*, the *magnetical*, the *swampy*, and the *sandy ones*. The whole island seems in fact to be a group of iron-mountains : its ores in general produce the best kind of malleable iron : and very great advantages would arise from these mines, if more skilful managers were employed in conducting their works. *The Editor, from F. Pini, Coudrai, Mongez, and Ferber's observations.*

It

It is remarkable, that, when these ores are found together with marcasite, those particles, which have laid nearest to the marcasite, are attracted by the loadstone, although they yield a red or reddish-brown powder, like those which are not attracted by the loadstone.

It is likewise worth observation, that they generally contain a little sulphur, if they are imbedded in a lime-stone rock, which, however, very seldom happens in Sweden; but I know only one such instance, viz. at Billflo, in Soderberke, in the province of Dalarne. Sect. 345.

S E C T. 337. (204.)

Black Hematites.

2. Blackish-brown bloodstone, *Hematites nigrescens*. Kidney ore.

This yields a red-brown powder when it is rubbed; it is very hard, and is not attracted by the loadstone.

- a. Solid, with a glassy texture, from Westersilfverberget, in the province of Westmanland.

- b. Radiated.

- c. Crystallised.

1. In form of cones, from Siberia.

2. In form of concentrick balls, with facets.

These are very common in Germany, but very scarce in Sweden.

S E C T. 338. (205.)

Red Hæmatites.

3. Blood-red, *Hæmatites ruber*. Red kidney ore.
- a. Solid, and dim in its texture, from Westfælfverberget, in Westmandland.
 - b. Scaly. The *Eisenram* of the Germans. This is commonly found with the iron-coloured iron-glimmer (Sect. 336. d. 1.), and smears the hands.
 - c. Crystallized.
 - 1. In concentrick balls, with a flat or faceted surface.

S E C T. 339. (206.)

Yellow Hæmatites.

4. Yellow bloodstone, *Hæmatites flavus*.
- a. Solid.
 - b. Fibrous, from Lammerhof, in Bohemia [a].

S E C T.

[a] This yellow blood stone, when reduced into powder, retains the same colour it had before: as has been already remarked in the note [a], to Sect. 336, p. 724. *The Editor.*

The varieties of the colours in the blood stones are the same as those produced in the calces of iron, made by *dry* or *liquid* menstrua, and exposed to different degrees of heat. *The Author.*

See

S E C T. 340. (207.)

Heterogeneous iron-ores.

2. Iron in form of calx, mixed with heterogeneous substances. *Minera ferri calciformis heterogeneis mixta.*

a. With a calcareous earth. White spathose iron ore. The *Stablsstein* of the Germans. See Sect. 36 [a].

With

See the note to Section 248. upon the succession of colours exhibited by iron, when it is growing hot. *The Editor.*

Yellow ochres are distinguished from clays, by containing a larger portion of martial particles; those that become brown and magnetic by calcination, belong to this species. Sometimes the ferrugineous particles are mixed with argill, and calcareous, or muriatic earths; and then these ochres effervesce with acids. Kirwan, Sp. 8.

[a] The *Stablsstein*, or *Weiss Eisen Spath* of the Germans, is whitish, when fresh dug; but it becomes grey afterwards, then brown, at last reddish, yellowish, and black. It is either amorphous, or rhomboidal; is frequently transparent, and of a lamellar texture, or scaly, granular, or cellular. Sometimes it assumes a stalactitical form, and sometimes is found in a powdery state; in this last case it is of a brown-blackish colour; is frequently interspersed with quartz, pyrites, shorl, zeolyte, mica, and asbestos. It will not give fire with steel, unless these foreign substances be struck.

Its specific gravity is from 3,600 to 3,895, or 4,000. It effervesces feebly with acids, particularly when pounded and heated. It is scarcely ever magnetical before calcination; but, if heated, it decrepitates, grows black, becomes magnetic, and loses from 15 to 40 per cent. of its weight. 100 parts of this ore from *Eisenartz* in *Stiria* afford, according

b. With a siliceous earth. The martial jasper, or sinople. Sect. 108. [b].

With

to Bergman, 38 of brown calx of iron, 24 of white calx of manganese, and 38 of mild calcareous earth. That of *West Silesberg* contains 22 of the said calx of iron, 28 of manganese, and 50 of mild calcareous earth.

N. B. The aerial acid is not only united to this last earth, but also to the metallic calces.

When this ore bears a stalactitical appearance, and is very white, it is called *Flos Ferri*, and *Eisen Bluth*. This affords 27 per cent. of reguline iron, according to Rinman; and consequently 35 of the brown calx. *Editor, from Kirwan, Sp. 5.*

Besides the *Stahlstein*, mentioned by the author, there is a red calcareous iron ore found in many parts of England, in a loose form. It effervesces strongly with acids, and is used as a pigment. *Kirwan, Sp. 14.*

[b] Besides the two siliceous combinations, mentioned by the author in these two last articles, the *jasper*, *garnet*, and *trapp*, (which last will be mentioned in the Appendix among the *volcanic production*), and various other compound substances, contain iron. There is found, principally in France, a *black, heavy, unmagnetic sand*, of the siliceous kind, which is said to contain iron and zinc in great quantity.

The *black sand* from Virginia contains about half its weight of iron, and is magnetic. Its specific gravity is = 4,600, but its composition has not yet been discovered. *Kirwan, Sp. 6.*

It appears, by the account inserted in the *Philos. Transactions* for 1763, p. 56, that there are very large quantities of this *sand-iron-ore* in Virginia, perhaps as large as of any other kinds of iron-ore. It is so pure, that it required a mixture of *boz-ore*, or of *slags* from other smeltings, to reduce it to a metallic form. The iron and steel produced from it, was above 60 per cent. (or 50 from 85): the quality both of the *iron* and of the *steel*, made out of this ore, was extremely good, and two small bars of the same were sent, as a sample, to the Museum of the Royal Society of London.

Large

- c. With a garnet earth. Garnet and cockle,
or shirl. Sect. 115 to 123.
d. With an argillaceous earth. The bole.
Sect. 134 to 136. [c].

With

Large strata of black-sand iron-ore are found in various places of Portugal, even at a considerable distance from the sea-shore, and from any running waters; a very great part of this black-sand is attracted by the magnet; but I do not know, whether its component parts have ever been properly examined. *The Editor.*

Baron Born, in his letters from Hungary, quoted by Mr. Kirwan, mentions a blue crystallized iron-ore, which he says is a *fourle* over-loaded with iron, *See also the note to p. 212.*

The same Mr. Kirwan, at p. 143 of his *Elements of Mineralogy*, speaks of a siliceous sand, consolidated by semi-phlogisticated calx of iron, which does not crumble into sand when powdered. It is generally of a *brown* or *black* colour; but grows *reddish* or *yellowish*, and moulders by exposure to the air. Its specific gravity is from 2,800 to 3,600: it gives fire with steel, and does not effervesce with acids, unless it contains testaceous particles, as it frequently does, and is even often covered with shells.

He adds, that the agglutinating power of solutions of iron has been shewn by a stony concretion of this sort, that had been long buried in the sea, and is mentioned in a paper of Mr. Edward King, inserted in the *Philos. Transactions* for 1779, p. 35. Mr. Rinnan has found, by experiment, that dephlogisticated calces of iron, and particularly its solutions made by mineral acids, have no binding power; on the contrary, they only make loose concretions. *Kirwan.*

[c] The argillaceous iron-ores may be distinguished into two varieties, namely, those found in mountains and high lands, and those found in swampy grounds, and low lands overflowed with water; both are destitute of metallic lustre, but very weighty, and some of them, when dry, absorb water like clay.

The Highland ochraceous-ores of the argillaceous kind are either of a *yellow*, *red*, *brown*, or *greyish* colour; are friable,

e. With a micaceous earth. Mica. Sect. 65. [*d*].

f. With manganese. [*e*].

friable, loose, and powdery, or in *grains*. They consist chiefly of the calx of iron, in a loose form, mixed with argill or clay, and frequently contain manganese: some in *France*; and ~~in the neighbourhood of Liege~~, contain also the calx of *zinc*. They do not effervesce with acids, unless calcareous or muriatic earths be mixed with them; and never obey the magnet before calcination, and rarely after it.

Horn stone, overloaded with iron, belongs to this species.

Rinman mentions a *white* iron-ore, found in *Kent*, mixed with clay, or marl, which affords 47 *per cent.* of brittle iron; and is scarcely soluble in acids.

The *swampy* or *lacustris* iron-ore is friable, brown, brownish, or black. It is found either in lumps, of an irregular shape, or in balls or in grains; and also in slender triangular prisms parallel to each other. It is mixed with argill, and extractive matter: becomes magnetic after calcination, by which it loses about $\frac{1}{4}$ of its weight, whose greater part is water, and the remainder is aerial acid and volatile alkali. The crude ore affords about 30 *per cent.* of regulus; and, after calcination, about 50 *per cent.* The iron produced from this ore, chiefly that in *Sweden*, is of the *cold-short* kind. Mr. *Hielm* found some sorts of this ore, which contain 28 *per cent.* of manganese. *The Editor, from Kirwan.* 3.

[*d*] When the *micaceous iron-ores* produce a red colour on being rubbed between the fingers, they belong to the *hematite* kind; and have been mentioned in note [*a*] to Sect. 336. But there are others that properly belong to this section; such is, for instance, that kind of serpentine overloaded with iron, which may be called *muriatic iron-ore*; but it is seldom worked, if ever, to extract the metal. *The Editor, from Kirwan.*

[*e*] The iron ores, mixed with manganese, have been already mentioned in the two preceding notes [*a*] and [*c*]. *The Editor.*

S E C T. 341. (208.)

Native Prussian blue, or *Alkaline Iron-ore*.

g. With an alkali and phlogiston. *Calx martialis phlogisto juncta, et alkali precipitata*. Blue martial earth. Native Prussian-like blue.

1. Loose or powdery, found among the turf in the levels of the province of Skone: also in Sax Weissenfels, and at Norvlanden in Norway, &c. [a].

S E C T.

[a] This ore consists of clay mixed with iron, and some unknown tinging substance. It is generally found in swampy grounds or bogs. At first its colour is white; but when exposed to the air, it becomes either of a *white*, or of a deep *blue*.

When heated, it turns greenish, and emits a slight flame; afterwards turns red, and magnetic.

Is soluble in acids and alkalis, but the latter precipitate it from the former, and the former from the latter. The precipitate is at first greenish; but gradually assumes a white hue; and recovers the blue tinge, if it be steeped in vegetable astringents. The earth of *Bathnitz*, in *Silesia*, seems to belong to this kind. It produces $\frac{1}{4}$ of its weight of iron.

Mr. Woulf found also this kind of ore in Scotland, on the surface of the earth, in the form of a fine white powder. The greatest part of marshy grounds, where the turf is found, generally contains some of this kind of iron ore. *The Editor, from Kirwan and Mongez.*

The *Terre verte*, called *Earth of Verona* and *Normandy*, is used as a pigment, and contains iron in some unknown state, mixed with *clay*; and sometimes with *chalk* and *pyrites*. Alum
and

2. Indurated, *Cementum induratum*, from Cologne [c].

This is of a whitish-yellow colour, contains likewise a great deal of iron, and has the same quality with the former, to harden soon in water, when mixed with mortar. This quality cannot be owing to the iron alone, but rather to some particular modification of it, occasioned by some accidental causes; because these varieties rarely happen at any other places, except where volcanos have been, or still exist, in the neighbourhood.

S E C T. 343. (211.)

B. Dissolved, or mineralised Iron. *Ferrum mineralisatum*.

1. With sulphur alone.

a. Perfectly saturated with sulphur, *Ferrum sulphure saturatum*. Marcasite. See Sulphur, Sect. 254.

b. With very little sulphur. Black iron ore. Iron stone. *Minera ferri atra* [a].

This

[c] Mention has been made already in Sect. 132. p. 234, of a *colnisch pipe clay*, which, when indurated, may answer to this *cementum induratum*, spoken of in the present Section. But this I must leave to the judgement of the reader, as I have no other clear idea of this substance. *The Editor*.

[a] This is the *Stahlertz*, or *ferrum chalybeatum*, of Linnæus; viz. a brown calx of iron, mixed with iron

This is either attracted by the loadstone, or is a loadstone itself, attracting iron; it resembles iron, and yields a black powder when rubbed.

1. Magnetic iron-ore, *Minera ferri attractoria* The Loadstone, *Magnes* [b].

in its metallic state. Is of a dark steel colour, solid, compact, and shining in its fracture; scarcely gives fire with steel, produces a black powder; is magnetic, and, in some degree, malleable when red-hot. It affords from 60 to 80 per cent. of good iron. It is found at *Adelfors*, and *Danneborg* in Sweden; also in the *Isle of Elbe*, and *North America*. *Kirwan*.

The *crystallized iron ore* belongs to this kind. It is in an octahedral, or cubic form: is the *ferrum tessulure* of Linnæus, and the *minera ferri crystallifera* of Wallerius; it is somewhat less magnetic than the preceding ore; probably because it contains less of the metallized iron. *Kirwan*, pag. 271.

[b] This differs but little in its appearance from the preceding ore, but has less lustre. It is either coarse or fine grained. The coarse grained loses its power soonest. It seems to contain a small quantity of sulphur, as it smells of it when red-hot. It is probable that it contains more particles of iron in its metallic state than the preceding ore; but it is often contaminated with a mixture of *quartz* and *argill*. It is possible it may contain *nickel*; for this, when purified to a certain degree, acquires the properties of a magnet. Its constitution has not yet been properly examined. *Kirwan*, Spec. 3.

The magnetical attraction seems to stand alone among natural phenomena. Philosophers observe its effect with surprise and admiration, whilst the most cautious and rational are obliged to confess that the cause is intirely unknown, as *Nicholson* observes (Book 3. Sect. 2); but, although this cause be not felt nor perceived by any of our senses, we are absolutely compelled to allow the existence of an extremely subtle matter, which is capable of producing this effect. Perhaps! time will discover, whether it be coercible by any other substance; or what is necessary to be done before it can be exhibited alone, or in a separate state. *The Editor*.

B b b

Steel-

- a. Steel-grained, of a dim texture, from Hogberget, in the parish of Gagnef in Dalarna: It is found at that place almost to the day, and is of as great strength, as any natural loadstones are ever commonly found.
- b. Fine-grained, from Saxony.
- c. Coarse-grained, from Spetalsgrufvan, at Norberg, and Kierrgrufvan, both in the province of Westmanland. This very soon loses its magnetical virtue.
- d. With coarse scales, found at Sandswær in Norway. This is a pyritical *Eisenman*, and yields a red powder when rubbed. Sect. 336.

S E C T. 344. (212.)

2. Refractory iron-ore. *Minera ferri refractoria.*

This ore, in its crude state, is attracted by the loadstone.

- a. Giving a black powder when rubbed, *Tritura atra*. Of this kind are [a],
 - 1. Steel-grained, from Adelfors, in the province of Smoland.
 - 2. Fine-grained, from Dannemora, in the province of Upland.

[a] Probably the *iron-blende*, described by Mr. Monnet, and mentioned by Mr. Kirwan in his Sp. 23, belongs to this kind of ore. This iron-blende is a stone of a grey iron colour, formed of diverging laminæ, of great hardness, and a metallic appearance; but is insoluble in acids, and infusible in the strongest fire. Sometimes this stone contains arsenic; and in this case it blackens by exposure to the air. *The Editor.*

Coarse-

3. Coarse-grained, from Kierrgrufvan, in the province of Westmanland.

This kind is found in great quantities in all the Swedish iron mines; and of this most part of the fusible ores consist, because it is commonly found in such kinds of rocks as are fusible: and it is as seldom met with in quartz, as the hæmatites is met with in limestone.

§ E C T. 345. (213.)

b. Red-grained Iron ore, Tritura rubra.

This iron-ore differs from the preceding, on account of its rubbing into a red powder, *tritura rubra*.

These are real hæmatites, that are so far modified by sulphur or lime, as to be attracted by the loadstone [a].

1. Steel-grained, found in a deserted mine at Billbo, in the parish of Soderberke in Dalarna.

[a] These ores are very scarce in Sweden, for the most part of the Swedish blood-stones are pure, as has already been said, in the Sect. 336. They form that very profitable ore called in Swedish *Torrsten*. The Author.

The *Torrsten* consists of a red calx of iron, mixed with a small proportion of the brown ore; and is indurated. It is of a bright bluish-black, or yellowish-grey colour, and of a fibrous texture, shows a red trace when scratched, and is weakly magnetic before calcination. According to Rinman, it is less dephlogisticated than hæmatites. *The Editor from Kirwan, Sp. 10.*

B b b 2

Fine-

2. Fine-grained. Emery. This is imported from the Levant. It is mixed with mica, is strongly attracted by the loadstone, and smells of sulphur when put to the fire [b].
3. Of large shining cubes, from Thomsensgrube at Arendal in Norway.
4. Coarse, scaly. The *Eisenglimmer* or *Eisenman* from Gellebeck in Norway [b].

S E C T. 346. (214.)

Iron mineralised, or mixed.

Iron is found mineralised and mixed with various fossil substances.

Iron mineralised by sulphur. *Martial Pyrites* [c].

With

[b] Emery, according to *Kirwan*, *Sp.* 11, seems to be a mixture of the red and white calces of iron, with some unknown stony substance, perhaps *tripoli* (Sect. 143); it scarcely yields in hardness to any substance, except diamond.

The best sort is of a dark grey colour, but becomes brown, and in great measure magnetic by calcination.

Other sorts are of a reddish rusty white, or yellowish colour.

Its specific gravity is from 3,000 to 4,000.

It is never used as iron ore, nor is its proportion of iron well known. *The Editor*,

[c] The *martial Pyrites* are stony concretions of sulphur, clay, and calx of iron; so hard as to give fire with steel, from whence their name is derived. There are two principal varieties of them; the first is,

The

With arsenic, *Ferrum arsenico mineralifatum*;
 Called Mispickel by the Germans, and Plate
 Mundic in Cornwall [d].

With

The pale yellow pyrites, which are real iron ores, containing from $\frac{1}{2}$ to $\frac{3}{4}$ of sulphur, and from $\frac{1}{4}$ to $\frac{3}{4}$ of iron; the remainder is *argill* and *siliceous* earth, combined with each other, and the iron is in a semi-phlogisticated state.

They are of a yellow or grey colour, and of a globular, or cubic shape, internally radiated, and sometimes lamellar; commonly are partly soluble in *nitrous acid* with effervescence; and slowly in the *vitriolic*; with which they form alum. See Sect. 200.

They detonate slightly with nitre, and are very infusible. Their specific gravity is from 7,3000 to 4,912. See Sect. 254, and the following.

Some *pyrites*, instead of *argillaceous*, contain *calcareous* earth; these are common in *France*, and in them the iron is, according to *Monnet*, in a dephlogisticated state; *Pyrites* are frequently found in a stalactitical shape, and often form the matter of petrifications. They are also found mixed and interspersed through almost every other species of stone, except *granite*. According to the same *Monnet*, those pyrites which are of a *filamentous*, or *striated* texture, contain the least sulphur; and those of a *lamellar*, most: the last effloresce difficultly, if at all; and are said to contain from 25 to 35 *per cent.* of sulphur. *Kirwan*, pag. 190.

[d] The *Mispickel*, called *Speiss* by the Bohemians, is in general of a bright white, resembling a mixture of *silver* and *tin*; sometimes, though rarely, variegated, like a pigeon's neck, and not easily altered by exposure to the air. Its form is either granular, cuspidated, cuneiform, prismatic, or rhomboidal.

Is not magnetical before, nor after calcination; but when iron contains less than $\frac{1}{16}$ of arsenic, it is then magnetic; therefore, if the calcination of mispickel be pushed so far, the iron will remain magnetic.

Is soluble in acids, and affords arsenic by distillation, in the proportion of 30 or 40 *per cent.* and it sometimes contains a small proportion of *copper* and *silver*.

With sulphurated arsenic.

Arsenical Pyrites [c].

With vitriolic acid. Martial vitriol, Sect. 207 [d].

It is frequently mixed with other metallic ores, and often found in indurated clay, quartz, spar, shoerls, &c. *The Editor from Kirwan, Spec. 20.*

[c] This iron-ore is in the form of white grey pyrites, or marcasite; and is called by the Germans *Rauß gelb kiesel*, *Gist kiesel*, or *Arsenic stein*.

It is found either in solid compact masses of a moderate size, or in grains.

It gives fire with steel.

When burnt, it affords a blue flame, and an arsenical smell, like garlick.

By distillation it affords *orpiment*, or *realgar*.

It is not magnetic, either before or after calcination; and contains much more arsenic than sulphur.

It is analysed by digestion in *marine* acid, to which the *nitrous* must be gradually added; otherwise the sulphur would be destroyed.

The *marine* acid will take up the *iron* and leave the arsenic; otherwise, if it be analysed by solution in *aqua regia*, both the *sulphur* and the *arsenic* will be dissolved; but, on adding water, the *arsenic* will be precipitated, and the *iron* will remain in the solution. The *silver* if any will remain in the form of horn-silver. *The Editor from Kirwan, Sp. 19 and 20.*

[d] This is a *brown*, or *reddish-brown* pyrites, called *Min. ra ferri hepatica* in Latin, and *Wasser Kiesel* in German. It is generally of a spherical shape, crystallized in cubic, rhomboidal, or other polyhedral forms, and has no metallic lustre.

It difficultly gives fire with steel, and contains very little sulphur, but much more iron than the yellow pyrites; and not unfrequently a mixture of *calcareous earth*. It is sometimes magnetic before, and always after, calcination. It is incapable of vitriolization. The iron it affords is brittle. *Kirwan, Sp. 18. Var. 2.*

With

With phlogiston. Martial coal-ore. Sect. 258. B. 1. 2. [e].

With other sulphurated and arsenicated metals. See these in their respective arrangements [f].

S E C T. 347. (215.)

Observations on Iron [a].

This metal enters into so many compositions, that they cannot all be possibly enumerated

[e] This combustible iron-ore, already described in Sect. 258, is a kind of coal, of which there are the two varieties there mentioned. The *volatil* seems to contain iron, *plumbago*, and *coal*, intimately mixed; and the other burns with a languid flame, loses about $\frac{1}{2}$ of its weight, and yields about 30 per cent. of iron. *Kirwan*, pag. 283.

[f] The combination of *sulphurated* iron with *zinc*, generally called *Calamine*, will be treated hereafter among the ores of that semi-metal.

That with the *Tungsten* mentioned by the Author in his Sect. 210, will be treated on the article of *Wolfram* among the semi-metals.

And that with *Manganese*, will be also treated on the Sections upon this semimetal. *The Editor*.

[a] 1. Iron is employed in three different states, each having its peculiar properties, by which they are each more particularly applicable to various purposes. The first is *cast-iron*, the second is *wrought* or *malleable iron*, and the third is called *Steel*.

According to *Bergman*, *cast iron*, which may be called *unripe* or *raw-iron*, contains the smallest share of phlogiston. The malleable iron contains the greatest quantity, and the *steel* a middling share between both, neither so much as the

B b b 4

malleable

rated; it must therefore suffice to mention only those, in which it makes the predominant part. This metal is found in animals and vegetables; and certain iron-ores seem to be of service to the

malleable, nor so little as the *cast-iron*. This last is called also *Pig-iron*, and *Yatlin* in England.

2. The richest ores of iron are the compact and ponderous, of a brownish, reddish-brown, or red colour. Some of these ores, in colour and appearance, do not ill resemble iron itself; as the grey ores of Derbyshire, and the bluish of the Forest of Dean in Gloucestershire. Most of the Swedish ores are likewise of this kind. Others are blackish, brown, red, yellowish, or rusty coloured, as have been described in the preceding Sections: these are the most common in England and Germany. There is one very singular species of a striated texture, and of a pale yellowish or greyish colour, oftentimes white, and in some degree pellucid; which, although in its crude state, promises nothing metallic; nevertheless, on being moderately calcined, discovers, by the deep colour it assumes, that it abounds in iron. Cramer informs us, that it gives out by fusion, from 30 to 60 per cent. But some richer ores yield no less than 70 and 80 on the hundred.

3. Different kinds of iron-ore are found adhering, in some mines, to the tops of caverns, in form of icicles or stræ, sometimes irregularly clustered together, sometimes hanging down like the bristles of a brush; from whence the name of *Brush-iron-ore*. Other particular forms of the iron stone have occasioned a variety of fanciful names, that are met with in some of the metallurgic writers.

4. The iron of Great Britain is made from three different kinds of ores: 1. From the iron-ore, called the *Lancashire ore*, from the county where it is found in greatest abundance. This ore is very heavy, of a fibrous or lamellated texture; it is of a dark purple, approaching to a shining black; and, when reduced to powder, it becomes of a *deep red*: it lies in veins like the ores of other metals: 2. The bog-ore, which resembles a *deep yellow* ochry clay, and seems to be the deposition of some ferruginaceous rivulets, whose currents had formerly

the vegetable kingdom, as it is manifestly seen on the ground, around and under the heaps of loose stones laid up on separating the ore from the rock, at those iron mines, where the ores are mixed with limestone.

With

merly been over the surface of those flat marshy plains. It lies in beds of irregular thickness, commonly from 12 to 20 *inches*, and very various in their breadths from side to side, never being of great dimensions. 3. The iron-stones, however, have no regular appearance, and do not in the least resemble a metal in their external surface. They lie often in beds of great extent, like other stony matters, and are sometimes stratified with seams of pit-coal, forming alternate layers.

5. The ores of iron are commonly calcined, previous to the fusion, even the harder ones, though they should contain nothing *sulphureous* or *arsenical*, in order to calcine the hard adhering matrices, and render the masses soft enough to be easily broken into fragments of a convenient size for melting. After the mineral is duly prepared, it must be smelted in furnaces of large capacities, from 16 to 25 *feet* high, and from 10 to 14 wide: the most approved shape nearly resembles that of a hen's egg, with the largest end undermost, below which is a square cavity to contain the melted metal, and at the top a very short vent about 20 *inches* in diameter. The inner wall is built of fire stone, which endures very strong heat with little risk of melting, and all the joints are cemented with mortar composed of sand and clay. This is surrounded with more building, which deviates more and more from a circular form, and becomes a square building of about 20 feet at the base, and gradually converges to the top.

6. Near the bottom is an aperture, for the insertion of the pipe of a large bellows, worked by water, or by other machines that may produce a strong current of air. Some very powerful ones I have seen in the iron works at *Colebrook dale*, and consist of two iron cylinders, about two or more feet wide, whose pistons are alternately moved by a small fire engine; but Mr. Wilkinson very ingeniously adapted to his
own,

With respect to the oeconomic effects, iron is divided into *cold-short*, *red-short*, and *tough*; and the ores into *refractory*, *fusible*, and those that do not want any admixture; which depends

own, a large vaulted receiver surrounded by water, which produces a very regular and uniform blast. Two or more holes are also left ready to be occasionally opened at the bottom of the furnace, to permit, at a proper time, the scoria and the metal to flow out, as the process may require. Charcoal, or coke with lighted brushwood, is first thrown in: and when the inside of the furnace has acquired a strong ignition, the ore is thrown in by small quantities at a time, with more of the fuel; and commonly a portion of lime-stone is thrown also, as a flux. The ore gradually subsides into the hottest part of the furnace, where it becomes fused; and the metallic parts, being revived by the coal, pass through the scoria, and fall to the lower part, or bottom of the furnace, where a passage is open for taking off the scum or dross. The metal now, in strong fusion, is let out, by a tap-hole, into furrows made in a bed of sand: the large mass, which sets in the main furrow, is called by the workmen a *cow*, and the lesser ones *pigs* of iron. *Chimney-backs*, *floues*, *garden-rollers*, &c. are formed of this rough metal, taken out of the receiver with ladles, and cast into moulds made of fine sand.

7. The quantity of fuel, the additions, and the heat must be regulated, in order to obtain iron of good quality; and this quality must likewise, in the first product, be necessarily different, according to the nature of the parts that compose the ore.

8. Two or 3 tons, viz. 4, or 6,000 pounds weight of iron, are now run off in 24 hours, at some large furnaces, after the application of the large bellows; whilst scarcely an hundred weight could be obtained in a day before that application, because a large quantity of the metal was left in the dross; hence, in some places, the slags of different ores, left by old operators in former times, are now re-melted to advantage along with fresh ore; and, on account of the richness of these old slags of different ores, some people have been misled

on accidental circumstances, and the
 of working.

though iron is commonly mixed in the
 kinds of earths; yet it cannot be af-
 ferted

into the opinion, that the metal was regenerated in

at and turf has been found to answer tolerably well,
 with charcoal, for the smelting of iron-ores; but I am
 d, that the attempt I mentioned of its use at p. 485,
 has been found not to answer the expectations that
 were conceived from the first trials. *Pit-coal*, if applied
 for the same purpose, renders the *iron* hard and brittle;
 this inconvenience is prevented, by previously coak-
 ing the coal, and employing it in the state of true *coak*.
 Mr. in his *Art of Assaying*, p. 347. says, that *pit-coals*,
Welsh-coals, and *Scotch-coals*, which burn to a white-ash like
 and abound more in bitumen, may be used in the first
 smelting of the iron from its ore; and if the iron proves not so
 malleable as required, this property may be given to it, by
 re-smelting the metal a second time with wood.

The best *cast-iron*, or *raw-iron*, as much freed from
 heterogeneous matters, as the usual process of smelting can
 produce, is not at all malleable, and so hard as perfectly to
 resist the file.

In general the impure cast iron, as run from the ore,
 is re-smelted down a second time in another furnace, intermixt
 with charcoal. A strong blast of air being impelled on the
 surface of the metal, its fusion is remarkably promoted; the
 metal thickens into a mass called a *loop*, which is conveyed un-
 der a large hammer raised by the motion of a water-wheel.
 The iron is there beaten into a thick square form, is then
 re-smelted again until almost ready to melt; and is forged: by
 repetitions of this process, it becomes completely *malleable*-
 and is at length formed into bars for sale.

Iron in this state of *malleability*, is much softer than
 the crude, and of a fibrous texture. But if it is still crude and
 heterogeneous, after the above process, it shews that there have re-
 mained heterogeneous matters, being hidden in its interstices,
 which must be expelled; for this purpose the iron must be
 stratified

serted with Becher, that iron may be melted out of every earth, by adding only a phlogiston; since in that case this metal might also be got out of *Muscovy glass, pure quartz, chalk, white*

stratified with charcoal-dust within a proper furnace, heaped up in good quantity in *strata*; then the fire must be blown pretty strongly, so as to bring it to a fusion, which is to be helped by the addition of fusible scorias, or of sand. The fire must not be much greater than necessary to make all these melt as equally as possible; to obtain this end, the melted mass must be agitated here and there with poking rods of wrought iron, in order to make every part feel alike the action of the fire and air; and the increasing scorias taken out once or twice.

13. In the mean time a great many sparkles will be thrown out from the iron, which diminish the more as the iron comes nearer to the desired degree of purity, but they never cease entirely. The burning coals being then removed, and the scoria conveyed out of the fire, through a channel made for that purpose; the iron, by lessening the violence of the fire, grows solid, and must be taken out red-hot, and tried by striking it with a hammer. If it proves crude still, let the melting be repeated; and when it is at last sufficiently purified, it is to be hammered, and extended various ways, by making it red-hot many times over; this done, it will no longer be brittle, even when cold, as Cramer asserts.

14. Cast iron has of late been brought into the malleable state, by passing it through rollers, instead of forging it. Indeed this seems to be a real improvement in the process, as well in point of dispatch, as in its not requiring that skill and dexterity, which forge-men only acquire by long practice. If the purposes of commerce should require more iron to be made, it will be easy to fabricate and erect rolling machines, though it might be impracticable to procure expert forge-men in a short time.

15. This method was discovered by Henry Cort of Gosport, who obtained an exclusive privilege, granted by the king's patent. By this process the raw or cast-iron is freed from

white transparent fluor, &c. which probably has never yet been done.

Nature has bestowed on Sweden an immense store of iron ores; so that whole mountains, in Tornea and Lappmark in Lapland, consist solely of a pure, and a very rich iron-ore.

from the impurities, which are not discharged in the common methods of rendering this metal malleable; for iron is in itself a simple homogeneous metal; and all iron must become equally good, if it be purified from the heterogeneous and unmetallic particles that are any ways mixed with it.

16. The ordinary method of converting *cast iron* into *malleable*, is, as have been seen, by employing great quantities of charcoal, which furnishes phlogiston, and remetalizes the particles, which are unmetallized, and mixed with the heterogeneous matters contained in the fused mass: but in *Cort's method* there is no need of charcoal, instead of which, only *sea-coal* is employed; because the object is not to remetalize, but only to expell what is unmetallic; instead of endeavouring to restore the calcined parts with charcoal at a great expence, and still leaving the business undone.

a. The iron is only heated and wrought simply by the heat of the flame, instead of being mixed with the burning fuel and ashes, which are not easily disengaged afterwards from the metal.

b. The method of squeezing it between the rollers, forces out the melted slags from the metallic pores, and brings its metallic fibres into a perfect solidity, and close contact, so that they are obliged to cohere much more perfectly to each other, than by the interrupted and partial action of the hammer.

d. By the operation of being long stirred, the sulphureous particles are more disposed to be disengaged, and are burned away in the form of blue sparks; the metal then begins to curdle, and to lose its fusibility, like solder when it just begins to settle; the metallic particles meeting and coalescing together, much like the churning of milk, where the cream is separated by the union formed between the

ore. Large veins of the same ore are likewise found, in almost every province of that kingdom, of such a nature, that few countries can produce better or richer.

The magnetical power, with respect to its principles and origin, is no better understood than

the fibrous particles of the cheese. The curdles formed into a connected mass become what is called *loops*. The process is as follows:

17. Five or 6 hundred weight of raw, *cast-iron* (and even of *cold-short* iron), is brought into a low fusion, on a kind of hearth, or low furnace, in which it lyes to the depth of about 6 inches. One or two workmen continually stir this fused mass, with long iron pokers, for about 4 or 5 hours. The heat is then lowered: the men fashion the iron into narrow pieces of about $3\frac{1}{2}$ feet long, and 3 inches square, with long knives or chisels made for that purpose. They are then heated to the welding degree, and hammered to expel and scatter the unmetallic dross. These slabs are then formed to a wedge point at one end, in order to adapt them to be received between the rollers: they are malleable already, but they contain still some dross.

18. They are then heated again to the hottest welding heat in the air furnace: and immediately passed through large iron-rollers, turned by a water-wheel, or by horses. If the end presented to the rollers should slip, instead of entering, a boy who stands ready, throws some sand upon the iron, and it goes in easily. Much foreign and heterogeneous matter is squeezed out by the rollers; and the iron comes out in a purer malleable state. The same heat will serve to pass the iron through two sets of rollers, which are grooved so as to fashion it into *nail-rods*, or other forms, according to the required purposes.

19. Various and repeated severe trials have been made in the Royal dock-yards of England, as I have been informed, in the presence of persons of knowledge and rank, to prove the *strength*, *malleability*, and *softness*, or *toughness* of this

than electricity, yet something more with respect to its effects. Though both these qualities are now considered as different powers, they may perhaps in time be regarded as something nearer allied to each other.

The

new iron; and it has proved to be equal, and even sometimes superior to the best Swedish iron. But I cannot conceive, indeed, by what singular fatality so great an improvement in manufacturing this most useful metal, has not yet been generally adopted by our English iron-masters.

20. *Steel* is iron in an intermediate state, between cast-iron and malleable iron, which is soft and tough. The iron, run from some German ores, is found to be a good steel, when forged only to a certain point.

But the best steel is usually made by cementation from the best forged iron, with matters chiefly of the inflammable kind. Two parts of pounded charcoal, and one of wood ashes, is esteemed a good cement. The charcoal dust may be made of *bones, horns, leather, and hairs* of animals, or of any of these ingredients, after they are burned in a close vessel, till they are black; these being pulverized, and mixed with wood-ashes, must be well mixed together. The iron bars should be of pure metal, not over thick, and quite free from heterogeneous matters: their flexibility, both when hot and when cold, is a very good sign thereof. A deep crucible, two or three inches higher than the bars, is to receive part of the cement, well pressed at the bottom, to the height of 1¹/₂ inch; and the bars are to be placed perpendicularly, about one inch distant from the sides of the vessel, and from each other. All the interstices are to be filled with the same cement, and the whole covered to the top with it; then a tile is applied to cover the vessel, stopping the joints with thin lute.

21. The crucible is then to be put in the furnace, and a strong fire is to be made that it be kept moderately red hot for 6 or 10 hours together; at the end of which time they will be found converted into steel. If the cementation be continued too long, the steel will become excessively brittle, incapable of being welded, and apt to crack and fly in forging,

The magnetical power is not innate in the iron, but is collected into it by degrees, as is verified by experiments; it may be expelled, it may vanish, and become collected again, as it

forging. On the contrary, steel cemented with absorbent earths is reduced to the state of forged iron.

22. Steel is further purified, for making the nicest kinds of instruments, such as *lancets*, *pen-knives*, *razors*, and *various pieces*, for the best kind of *watches*, *time-keepers*, or *chronometers*, and *Astronomical regulators*. This purification of steel, consists in melting it again with a strong, but regular, fire in a crucible, the better to free it from the heterogeneous parts, and little flaws, that may be contained in it. It is then called *cast-steel*, when fused into bars; which name, however, does not imply that the pieces, for instance the *cast-steel razors*, have been really cast in their present shape; for they must be forged from the bar, after it is cast. The fusion must have been perfect, so that the metallic parts be rendered uniform. The metal diminishes a little by this process, for a bar of common steel 36 inches long, will afterwards produce another only of 35; if properly fused and purified.

23. The *cast-steel* will not bear more than a *red heat*; otherwise it runs away, like sand under the hammer, if the heat is pushed to the *welding degree*. Dr. Watson says, that this manufacture of cast steel was introduced at Sheffield only about 40 years ago, by one Waller. I knew this man, who was still living about the year 1765; he dwelled at St. Bartholomew's close, and was a galloon-wire drawer by trade. The difficulty of procuring small cylinders of good steel, to flatten the wire for lace-work in his business, whose defect proceeded from the bad texture of the steel, set his imagination on the enquiry after a method of purifying the metal to a greater perfection: and he thought that a new fusion of it was the most likely to accomplish his views. After some trials, he at last succeeded; but it was soon known to others, who got the advantages for themselves, of which ill fate the real inventor very bitterly complained till the end of his life. His own name was even forgotten, as one Huntsman practised this art to such an extent, that *cast steel* was known under his sole name afterwards.

24. But

it were out of the air: since the natural load-stones for the most part occur in small veins to the day, whereas at a greater depth only refractory

24. But before this discovery, made by Waller in England, this kind of steel was made already in Germany, as Watson asserts; and from thence some small quantities were brought to England at a considerable price. Since that time this branch of business is carried on advantageously at Sheffield; for the manufactures there furnish a great abundance of broken tools and old bits of steel, at a penny a pound, which, after fusion and purification, sell for 10 or 12 times as much.

25. It is a valuable property of iron, after it is reduced into the state of steel, that though it is sufficiently soft when hot or when gradually cooled, to be formed without difficulty into various tools and utensils; yet it may be afterwards rendered more or less hard, even to an extreme degree, by simply plunging it, when red-hot, into cold water. This is called *tempering*. The hardness produced is greater in proportion, as the steel is hotter, and the water colder. Hence arises the superiority of this metal for making mechanic instruments or tools, by which all other metals, and even itself, are *filed*, *drilled*, and *cut*. The various degrees of hardness given to iron, depend on the quantity of ignition it possesses at the moment of being tempered, which is manifested by the succession of colours, exhibited on the surface of the metal, in the progress of its receiving the increasing heat. They are the *yellowish-white*, *yellow*, *gold-colour*, *purple*, *violet*, *deep-blue*, and *yellowish-white*; after which, the complete ignition takes place. They proceed from a kind of scorification on the surface of the heated metal.

26. A bar of clean white steel may be made to assume all the above colours at once, by placing one end in the fire, and keeping the other end out, which is supposed of a proper length to remain cold.

27. These colours serve as signs to direct the artist in tempering this metal. For though ignited steel, suddenly quenched in very cold water, proves excessively *hard* and *brittle*; yet it may be reduced to the required degree of temper, by heating

C c c

it,

fractory iron-ores are found. There is the same difference between an artificial magnet of Dr. Knight's, and a bar of steel, whether of the

it, till it exhibits a known colour. This is the method employed in this process by the artists. As soon as the piece of steel is completely ignited, they plunge it in a very cold water; and as soon as it loses its fiery appearance, they take it out, rub it quickly with a file, or on a plate covered with sand, that it may have a white surface. The heat, which is still within the metal, soon begins to produce the succession of colours. If a hard temper is desired, as soon as the *yellow tinge* appears, the piece is dipped again, and stirred about the cold water. If the *purple* appears before the dipping it, the temper will be fit for tools employed in working upon metals; if dipped while *blue*, it will be proper for springs, and for other instruments fit to cut all sorts of soft substances; but, if the last *pale colour* be waited for, the steel will not be hard at all.

29. This process shews, that the minutest particles of the metal are hurried by the fire into a violent motion among themselves; and, if the heat be suddenly checked, they remain forcibly stretched against each other, and retained out of their natural position; of course, they are prevented from receding or sliding to another point of mutual contact, neither can the metallic texture be then allowed to adapt itself to another shape or position, and receive a new form. On this account, almost all soft metals, if capable of being well hammered, do not fail of becoming harder and stiffer after the operation; and their specific gravities are accordingly increased, because the same quantity of matter is then compressed into a lesser volume; whilst it is well known, that hard-steel is specifically lighter than after it has been hammered, *viz.* in the proportion of 7,704 to 7,195, according to Musschenbroek.

30. It deserves notice, that a piece of iron is rendered considerably warm by hammering, so as to even become red hot. It seems that phlogiston is thereby squeezed out of the metal, and is immediately attracted or absorbed by the surrounding air, to which it has the greatest affinity; and being deprived of its own specific heat; this last becomes *insensible* on the metal. But after the iron has been completely

the same shape or not, as between a natural loadstone, and a blackish blue iron-ore; whence it is ridiculous to insist with a certain author, that

hammered once, it is asserted, that it cannot be rendered again *red hot* by the same operation, because no further compression can then be made.

31. Hard steel is the only metal that, being struck slantwise with the sharp edge of a flint, or of another hard stone, produces sparks of fire. The minute particles of the metal are driven off with extreme rapidity, their phlogiston is set loose, instantly attracted by the air, whose *specific heat*, or *fire*, rushes into the metallic particles, inflames, and burns them; and they become truly calcined into scoria, as may be seen when examined with a magnifier; for they are mostly, as little hollow balls, about one hundredth of an inch in diameter, of black or greyish colours, like the cinders of a black-smith's forge.

32. The theoretic solution of the two last phenomena have been lately rejected by the *modern aerial, French Philosophers*, who absolutely deny the very existence of what has been called *phlogiston* since the time of Stahl; but, until they can give a more intelligible and a better grounded etiology of these facts, by the evident properties of *their airs*, every philosopher remains at liberty to disregard their opposition.

33. P. S. I had forgot to observe upon the text *l*, p. 719. that iron is often manufactured so as to be 150 times, and even above 630 times more valuable than gold. I lately weighed some common watch *pendulum-springs* at Mr. Tho. Wright's watch-maker to the King, such as are sold at *half a crown* by the London artists for common work; and ten of them weighed but *one* single grain. Hence *one* pound avoirdupois (= 7000 gr.) contains *ten times* as many of these springs; which, at half a crown apiece, amount to 8750 *pounds sterl.* The troy ounce of gold sells at 4 pounds sterling, and the pound (= 5760 gr.) at 48 pounds sterl. which gives 58,33 (or 58 pounds 6 shillings and 7 pence) for each pound *avoirdupois* of gold: and of course $\frac{48}{1,33} = 150$.

34. But the *pendulum-springs* of the best kind of watches, sell at *half a guinea* each: and at this rate, the above mentioned value must be increased in the ratio of 1. to 4,2: viz.

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of

that no iron-ore can be attracted by the load-stone, but what of itself contains some magnetical virtue.

of *half a crown*, to *half a guinea*: which will amount to 36750 pounds sterling; and this sum, divided by the value of this *pound* of gold, gives above 630 to the quotient.

35. N.B. 2. I should have noticed also at p. 750, that the attraction between the *iron* and the *load-stone* is the surest test to discover the presence of this metal in any ore whatever; for there is not any other body but iron, that is attracted by the natural load-stone, or by the artificial magnet, which has the very same property, and is composed of hard steel, properly impregnated with the magnetic power.

36. But very few iron ores are really attracted by the load-stone, before they have been made *red-hot*, as Cramer asserts. He directs, for this purpose, to reduce into powder the ore that is to be tried, by pounding it in a *brass-mortar*, but never in an *iron-one*: the powder is to be put in a crucible, well covered and luted, adding to the powder a small quantity of tallow: then being placed in a furnace, let it be made red-hot, for about one hour, in a strong fire. When cold, the powder is to be extended upon a sheet of smooth paper, and applying very near to it the load-stone, or the magnet; if there are any particles of iron, they will be attracted by, and will stick to it.

37. It is remarkable that iron, even adulterated with other metals, or semi-metals, without excepting arsenic, is not thereby rendered altogether unfit to be attracted by the natural or artificial load-stone; although the power of being attracted is lessened, but not extinguished, in proportion to the quantity of the extraneous matters

38. Antimony however is the only metallic body, that can prevent this attractive force between iron and the load stone, as the same author remarks. (N 360 of *Art of Essayng Metals*: p. 141.) He adds also that *sulphur* scarcely prevents the same attraction: but Maquer says positively, that sulphur is also a substance, that can hinder the reduced iron from being attracted by the load-stone. See the article Molybdene in his Chemical Dictionary. It is rather odd, that so little notice has been taken by other mineralogical writers and philosophers, of the action of these two substances on this general property of iron! The Editor, from Bergman, &c.

ORDER

ORDER THE THIRD.

Semi-metals.

S E C T. 348. (221.)

Bismuth, Tin-glafs. *Bismuthum*, *Marcasta officinalis*, Lat. *Åskbly*, Swed. *Wismuth*, Germ.

This femi-metal is [*a*],

a. Of a whitish yellow colour.

b. Of

[*a*] Bismuth, or vismuth, is the heaviest of all the brittle metals, called femi-metals.

Its specific gravity, according to Kirwan, is from 9,600 to 9,7000.

Nitrous acid, and *aqua regia*, dissolve it perfectly.

The *vitriolic acid* must be boiled nearly to dryness, before it acts upon this femimetal: and

The *muratic acid* only attacks its calx.

The quantity of phlogiston, which resists the action of menstrua on it, is expressed by 57; and its power of retaining it, ranks it in the *seventh* place.

It melts at the heat of 494 degrees. *Bergman*.

Its solution by nitrous acid is crytallifiable, into quadrilateral pyramids. *Wallerius*.

The addition of pure water to the nitrous solution of bismuth, precipitates its calx, and is the criterion by which this femimetal is distinguished from all other metals.

This white calx, called *Magistery of Bismuth*, is used by the fair sex, as a paint to whiten the skin, and improve the complexion; which, however, it gradually impairs

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very

- b. Of a laminated texture, yielding under the hammer, and nevertheless very brittle.
- c. Its specific gravity to water is, as 9,700 :: 1000.
- d. It is very fusible, calcines and scorifies like lead, if not rather easier, and therefore it works on the cuppel. It is considerably volatile in the fire.
- e. Its glass or slag becomes yellowish brown, and has the quality of retaining some part of the gold, if that metal has been melted, calcined, and vitrified with it.
- f. It may be mixed with the other metals, except cobalt and zink, making them white and brittle,

very remarkably. Strong smells, sulphureous vapours, and very odorous emanations, immediately turn this cosmetic into a brown or black colour.

The magistery of bismuth appears to have indeed some latent corrosive quality; and, when freely used as a cosmetic, must be very hurtful. It gradually impairs the natural complexion; and leaves, for old age, a coarse, disagreeable, and ugly skin.

It is said that this magistery produces a whiteness in *grey, reddish, yellow, or other coloured* hair; but the contrary is evinced by experiment; for it changes the whitest flaxen hair first to a *yellowish*, then to a *yellowish-brown*, afterwards to a *dark-brown*, and at last to a *blackish* colour.

The trial may be made in two ways; by boiling the hair in water, along with the magistery; or by applying the magistery mixed with pomatum, or hanging the hair in the sun greased with it. The oftener this is repeated, the darker will the colour be. We may therefore judge from hence, that this magistery is less fit for the purpose of cosmetic, than any other, that ever was recommended to the fair sex,

Moët

- g.* It is soluble in aqua-fortis, without imparting to it any colour; but to the aqua-regia it gives a red colour, and may be precipitated out, of both these solutions with pure water, into a white-powder, which is called *Spanish white*. It is also precipitated by the acid of sea-salt, which last unites with it, and makes the *Vismutum corneum*.
- h.* It amalgamates easily with quicksilver. Other metals are so far attenuated by the bismuth, when mixed with it, as to be strained or forced along with the quicksilver through skins or leather.

S E C T. 349. (222.)

Native Bismuth.

Bismuth is found in the earth.

A. Native, Vismutum Nativum [b].

Most metallic substances unite with bismuth, and are rendered more fusible by its addition.

It is used in making *pewter*, *printers types*, *folder*, &c.

The great fusibility of the mixture of bismuth, tin, and lead, renders it of a great use in making collars for the axles of some mechanical instruments to run in. *The Editor from Neumann, Nicholson, &c.*

[*b*] This is the most common of all native metallic substances; and is generally found either in cubes, or octagons; or of a dendritical form; or in that of thin laminæ, investing the ores of other metals, particularly those of Cobalt; from which is easily distinguished and separated by its great fusibility.

It is said to be sometimes found alloyed with silver. In such case it may be easily separated by its solution in nitrous acid;

This resembles a regulus of bismuth, but consists of smaller scales or plates.

1. Superficial, or in crusts.

2. Solid, and composed of small cubes.

This is found in, and with, the cobalt ore, at Schneeberg in Saxony, and other foreign places: Likewise along with the copper ore, at Nyberget in the parish of Stora Skedwi, in the province of Dalarne,

S E C T. 350. (223.)

Bismuth Calciform.

B. In form of calx, *Vismutum calciforme.*

1. Powdery or friable, *Ochra vismuti.*

This is of a whitish yellow colour: it is found in form of an efflorescence, to the day, at Los, in the province of Helſingland.

It has been customary to give the name of *Flowers of Bismuth* to the pale red calx of *cobalt*, but it is wrong; because neither the calx of bismuth, nor its solutions, become red, this being a quality belonging to the *cobalt* [c].

I have

acid; for, by the addition of water, the bismuth only will be separated, and any other metal will remain in the solution.

Native bismuth is of a yellowish white colour; and so fusible as to melt at the flame of a candle, when pure. *The Editor from Kirwan and Wallerius.*

[c] There are *greenish-yellow* calces of bismuth, frequently found with glittering particles, interspersed through stones of various

I have seen a radiated cristallisation of a metallic appearance, which was found at Schneeberg, and was likewise called *Bismuth Flowers*; but in the small trial I was permitted to make on it, it did not discover the least marks of bismuth, but answered rather to *zink*, if *zink* may be supposed to exist in a native state.

S E C T. 351. (Additional.)

Bismuth mineralized by vitriolic acid.

This ore is called *Wismuth Blut* by the Germans. It is said to be of a yellowish, reddish, or variegated colour; and to be found mixed with the calx of bismuth, incrusting other ores. From *Kirwan*, p. 334.

S E C T. 352. (224.)

(Mineralised Bismuth, *Vismutum sulphure mineralisatum* [d].)

This is, with respect to colour and appearance, like the coarse tessellated potter's lead ore;

various kinds; silver, and other metals, are also found in this kind of ore: from all which it is separable by solution in *nitrous acid*, as has been said in note [a] to p. 759. *Kirwan*, p. 333.

[d] This is chiefly found in Sweden; is of a bluish grey colour, of a lamellar texture, and tessellar form like *galena*; but much heavier.

ore ; but it consists of very thin square plates or flakes, from which it receives a radiated appearance, when broken crosswise.

1. With sulphur, *Vismutum sulphure mineralisatum*.
- a. With large plates or flakes, from Bastnas at Riddarhyttan, Bafringe and Stripas in Westmanland.
- b. With fine or small scales, from Jacobsgrufvan at Riddarhyttan, and the mines at Los, in the parish of Farila, in Helsingland.

S E C T. 353. (225.)

2. *Vismutum ferro sulphurato mineralisatum*.

2. With sulphurated iron.

- a. Of coarse, wedge-like scales, from Kongruben, at Gellebeck in Norway [e].

It sometimes presents parallel striæ like antimony ; and its colour is variegated. It is said to contain also *cobalt* and *arsenic*.

This ore is very fusible ; the sulphur mostly separates in scorification ; and it is soluble in nitrous acid. *From Kirwan* p. 334.

[e] This mineralised bismuth ore yields a fine radiated regulus ; for which reason it has been ranked among the antimonial ores, by those who have not taken proper care to melt a pure regulus, or destitute of sulphur, from it ; while others, who make no difference between regulus and pure metals, have still more positively asserted it to be only an antimonial ore. *The Author*.

In Schneeberg they have what is called *columbine bismuth*, and *plumose bismuth* ; the former has its name from its color, the

S E C T. 354. (Additional.)

Mineralised with Sulphur and Arsenic.

This ore of bismuth is of a whitish-yellow, or ash-colour [*f*]:

Has a shining appearance, and
Is composed of small scales or plates, intermixed very small yellow flakes.

It is of a hard and solid texture ;
Sometimes strikes fire with hard steel.
Has a disagreeable smell, when rubbed.

Does not effervesce with *aqua fortis* :
But is partially dissolved by the same acid.

This solution, being diluted with water, becomes a kind of sympathetic ink ; as the words

the latter from the texture. The latter is said to contain a great quantity of cobalt. *Bunnich*.

In the *dry way* this ore is extracted from its stony bed, by mixing 2 parts of the pulverized ore with one of pounded glass, and one of calcined borax, melting the whole in a crucible lined with charcoal. *Kirwan*, p. 335.

[*f*] 1. There is also a grey bismuth-ore, of the arsenicated kind, with a striated form, found at Helsingland in Sweden, and at *Annaberg* in Saxony.

2. Another ore of bismuth of the same kind, with variegated colours of *red*, *blue*, and yellow *grey*, is also found at *Schnaeberg* in Saxony.

3. Striated with green fibres like an *Amiantus*, at Misnia in Germany, and at *Gillebeck* in Norway.

4. With yellow-red shining particles, called *Mines de Bismuth Tigées* in French, at *Georgenstadt* in Germany, and at *Annaberg* in Saxony.

5. The *minera Bismuthi arenacea*, mentioned by Wallerius and Bomare, belongs also to the same kind of the arsenicated-ores. *The Editor*, chiefly from Bomare.

written

written with it on a white paper, and dried, are not distinguished by the eye; but, on being heated before the fire, they assume a yellowish-colour. This ore is found at *Rappolt*, and *Schneeberg* in Saxony. *Wallerius* and *Bo-mare*.

S E C T. 355. (226.)

Observations on Bismuth [g].

Although Mr. Pott has, in a separate Treatise on bismuth, shewn, that it is dissolved without giving

[g] Bismuth, or tin-glass, in its external appearance, has a great resemblance to *regulus of antimony* and *zinc*, differing little otherwise, than in the largeness of its plates or scales; and its contracting a yellowish cast on the surface, when exposed to the air. But as to its intrinsic properties, it is extremely different; melting far more easily, not evaporating so readily, being differently acted upon by acids, producing different effects upon other metallic bodies, &c.

When bismuth is kept in fusion, and is stirred, it soon calcines, gaining at the same time an increase in its weight of near half an ounce upon a pound.

The calx melts, on raising the fire a little, into a brownish or yellowish glass, which promotes the vitrification of earthen, and of the refractory metallic calces more powerfully: and corrodes and sinks through common crucibles more readily, than glass of lead itself.

If bismuth be mixed with gold or silver, a heat, that is but just sufficient to melt the mixture, will presently vitrify a part of the bismuth, which having no action on these perfect metals, separates and glazes the crucible all round.

It

giving any colour to the solution, and that it is precipitated with pure water; and, though the mine-master Mr. Brandt has likewise, in the *Acta Upsalienſia* for the year 1735, given an accurate history of the cobalt; we find nevertheless in some new authors such a definition of bismuth, as includes at the same time the principal characters of the cobalt, viz.

It melts a little later than tin; and seems to be the most fluid of all metallic substances.

When in fusion' it occupies less volume than in its solid state; a property peculiar to iron among metals, and itself among the semimetals.

It emits fumes in the fire as long as it preserves its metallic form. When calcined, or vitrified, it proves perfectly fixed.

Calx of bismuth, long reverberated, does not, as some pretend, become *red* like the calces of lead. It scarcely retains even the form of a calx; for a part of the bismuth is soon revived into its metallic appearance by the flame. None of the destructible metallic bodies is so easy of revival as this semimetal. If the vessel be covered, and all inflammable matters excluded, vitrification is the only change that ensues.

Bismuth cemented with sulphur, readily unites with it, and melts easier than by itself; but on continuing the fire, they soon separate again, the bismuth falling to the bottom, and a sulphureous scoria swimming on the surface.

Calx of bismuth likewise, very easily absorbs sulphur, and forms with it a curious needle-form mass, exactly resembling antimony, contracting a reddish tinge externally on exposure to the air. The quantity of sulphur imbibed is less than half the weight of the calx; a part of the sulphur having sublimed, when the operation was performed in a retort, in that proportion.

Silver added to this concrete, melts with it in a very gentle heat, into a brittle regulus. Gold also unites with it, but requires a much stronger fire: the compound is brittle, in appearance like an ore, with here and there some striæ or shining particles.

Copper

that of giving to glass a blue colour, and to tinge solutions red. This confusion proceeds from the bismuth being commonly found among cobalt ores, and not being separated from it but by the way of eliquation; during which the cobalt, as being less fusible, remains, and is by the workmen called *Vismut graupe*, or Bismuth grains.

This

Copper melts with it in a small heat, with remarkable facility; and after they have been united, the compound continues to retain its extraordinary fusibility. On the addition of lead to this compound, a new combination takes place; the copper and sulphur arise to the surface in scoria resembling an ore, whilst the bismuth and lead form a regulus at the bottom.

Zinc and bismuth do not unite together, the zinc flowing distinct upon the surface, and burning as it does by itself.

Mercury forms with bismuth an amalgam, which readily adheres to iron. If the iron, coated with the amalgam, be exposed to the fire, the mercury exhales, and greatest part of the bismuth remains fixed upon the iron, which then looks as if it had been silvered.

If mixtures of bismuth, with some other metals, particularly lead, be amalgamated, the lead is found to be so attenuated, as to pass with the quicksilver through leather. On standing, the bismuth is thrown up to the surface in form of a dark-coloured powder, the lead remaining dissolved in the quicksilver.

Equal parts of lead, tin, and bismuth, form a blackish sparkling compound, resembling the small-diced ores of lead.

The specific gravity of a mixture of bismuth and copper, is exactly the mean gravity of that of the two ingredients unmixed. But mixtures of it with iron are specifically lighter than the ingredients separately: whilst mixtures of bismuth with gold, silver, tin, lead, and regulus of antimony, are heavier than before by themselves separately.

Tin being too soft of itself for making vessels and utensils for common use, is generally worked with some additional
metallic

This error is excusable in those who do not pretend to maintain and vindicate their ignorance, it having been the fate of the semi-metals to be but very little examined. If the alchemists had not thought the quicksilver, antimony, and zink, fit for their purposes, we should very likely have still wanted many of those

metallic matters, of which bismuth is one of the principal. This mixed metal is called *pewter* in England, and constantly mistaken abroad for pure tin, being called by the name of this last metal. See the note N° 9 to page 643.

Bismuth being easier to fuse than lead or tin, is mixed with both to make a proper solder for each.

This semi-metal being reduced to powder, and applied, with the white of eggs, upon turned wood, makes it look as silvered, after it is dried, and properly rubbed over with a hard polisher.

Bismuth is preferable to lead for purifying gold and silver by cupellation, scorification, &c. For it more effectually promotes the destruction of the imperfect metals, and the vitrification of the earths, calces, or any refractory matters blended with them; as it procures a greater tenuity in the fusion, than lead is capable of producing. In all the operations of this kind, where sulphur makes one of the heterogeneous matters, bismuth is of the greatest advantage; namely, on account of its forming with that concrete an extremely fusible mass, whilst lead combined with sulphur, proves extremely refractory.

Bismuth has been too often employed for the adulteration of quicksilver, as rendering a very considerable proportion of lead intimately united with it. One part of this last metal, mixed with an equal one of bismuth, may be incorporated with three of quicksilver, without affecting its fluidity. Quicksilver thus adulterated is not only unfit for medicinal uses, but even for the common mechanic purposes of gilding and silvering; as the workmen find in this case, that it leaves upon the gold or silver a livid leaden hue, which spoils the proper fine appearance of the work.

those advantages which they afford both in medicine and common life.

Bismuth, it is true, has likewise in its time been in some favour with adepts; but it soon lost its credit: and was left to those who contented themselves with less prospects than

work. If the ash is separated, the mercury may be purified by distillation; although it appears by the observations of Boerhaave, that a very slight film is always acquired by the process. See the Note on p. 500.

Some say that the *lithmus* earth, or *terra martium* of bismuth, may be employed for making blue glass, in the same manner, as calcined cobalt; but when this happens, it only proceeds from the accidental mixture of cobalt, which is sometimes found naturally in the ores of bismuth.

A tincture is drawn from the ore of bismuth dissolved in *aqua fortis*, which being mixed with a saturated solution of sea-salt, and inspissated, yields a reddish salt: its watery solution is the curious liquor, called the *Green Sympathetic Ink*, though there is a real impropriety in calling it *green*, where it is in fact a red liquor. If any words are written with this ink on white paper, the characters disappear as soon as they are dry; but on holding the paper to the fire, they become *green* and legible: on cooling they disappear again, and this repeats any number of times.

According to Linnæus, the words written with this sympathetic ink may also be rendered legible, by wetting them with a sponge or pencil dipped in an aqueous solution of *hepar sulphuris*.

The experiments succeed best, when the tincture, drawn from the calcined ore of bismuth, is mixed with a solution of one fourth of its weight of sea-salt; this mixture is then evaporated almost to dryness, and the residuum is dissolved in water, which is then the sympathetic ink. If the tincture be mixed with nitre or borax, instead of sea salt, the characters will become *yellow* when warmed; and if sea-salt is afterwards added to them, they will become *blue*; but if mixed with alcohol sufficient to saturate the acid, they change to *purple* and *red* colour by heat.

Bismuth

than of making gold and the universal medicine; as to pewterers, tin-workers, and other tradesmen, who find their advantage in the fusibility of this semi-metal, and its giving colour and hardness to tin and lead.

S E C T. 356. (227.)

3. Zinc, Spelter. *Zincum*, *Marchasita aurea*, *Zinethum*, Lat. *Spiauter*, Swed.

General properties of Zink.

This semimetal is distinguished from other metallic substances by the following qualities:

- a. Its colour comes nearest to that of lead, but it does not so easily tarnish [a].

It

Bismuth is most commonly lodged in cobalt-ores; and, when they are of a high red, or peach-bloom colour, they are called *Bismuth bloom*, or *Flowers of Bismuth*. It was formerly believed, and some are still of opinion, that *Bismuth* gives to glass the same blue-colour as the cobalt does; because the dross which remains after the *Bismuth* has been melted out, called *Bismuth-grain* by the smelters, produces sometimes that effect. But, as no such grains or colouring earth remain from pure bismuth, it is plain that this quality must arise from something that was mixed with the bismuth, which undoubtedly is nothing else but some partial mixture of the cobalt ore, that was contained along with the bismuth. *Gellert's Metal. Chm.* pag. 61. *The Editor, chiefly from Neumann, Lewis, &c.*

[a] Zinc is the most malleable of all the semi-metals.

Its specific gravity is = 6862, according to Bergman; and Kirwin asserts it to be from 6,900 to 7,240.

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It

- b. It shews a texture, when it is broken, as if it were compounded of flat pyramids.
- c. Its specific gravity to water is, as 6,000 or 7000 :: 1000.
- d. It melts in the fire before it has acquired a glowing heat; but when it has gained that degree of heat, it burns with a flame of a changeable colour, between blue and yellow; and if in an open fire, the calx rises in form of soft *white flowers* [b]; but if in a covered vessel, with the addition of

It melts at a lower heat than *copper* or *silver*; but at a higher degree than *lead* or *tin*, according to *Kirwan*, pag. 312. Bergman affirms its melting to be at the 699° of Fahrenheit's thermometer.

When broken it looks as if its whole texture was a compound of loose cubical grains. *Gellert's Metall. Chymist.* chap. 7. p. 32.

It cannot be reduced into powder under the hammer like other semi-metals. When it is wanted very much divided, it must be granulated, by pouring it while fused into cold water: or filed, which is very tedious, as it stuffs and fills the teeth of the file. But if it be heated the most possible without fusing it, Macquer asserts, that it becomes so brittle as to be pulverised in a mortar.

This property is very different from that of metals, which become more ductile by the action of fire.

The facets which the pigs of zinc present in their fracture, indicate that it is crystallisable: and Mongez found that its crystallization consists of bundles of small quadrangular prisms, variously disposed on all sides, of a blue colour, which changes if exposed to the air. *Fourcroy*.

[b] These are called *Flowers of Zinc*, which are very fixed in the fire, and soluble in acids. *Kirwan*.

The calces of all metals and semi-metals may be reduced again into their metallic form, by the addition of proper phlogistic substances; but the white calx of zinc admits of no reduction. *Cramer*.

some

some inflammable substance, it is distilled in a metallic form ; in which operation, however, part of it is sometimes found vitrified.

- e. It unites with all the metals; except bismuth, and makes them volatile [c]. It is however not easy to unite it with iron without the addition of sulphur [d]. It has the

[c] Zinc also does not mix in fusion with Nickel, nor with Bismuth. How carefully soever it be stirred and mixed with either of these, the zinc, when grown cold, is found distinct upon the surface, so as to be readily separated by a blow.

It brightens the colour of iron almost into a silver hue ; changes that of copper to a yellow, or gold colour, as mentioned pag. 676. and note [g] pag. 707. but greatly debases the colour of gold and destroys its malleability. One hundredth part of zinc renders this most ductile metal brittle and intractable. A mixture of equal parts of gold and zinc forms a very hard, white metal, which bears a fine polish, and was proposed by Hellot for making specula of reflecting telescopes, as it never rusts nor tarnishes when exposed to the air.

It improves the colour and lustre of lead and tin, rendering them firmer, and consequently fitter for sundry mechanic uses. Lead will bear an equal weight of zinc, without losing too much of its malleability.

Arsenic, however, which whitens all other metals, renders zinc black and friable ; and when this mixture is made in close vessels, an agreeable aromatic odour is perceived on opening them. *Lewis.*

[d] Zinc, however, does not unite in the least with sulphur, or with crude antimony, which scorify all other metallic substances, except gold and platina ; nor with compositions of sulphur and fixed alkaline salts, as *liver of sulphur* ; which dissolve gold itself. Hence zinc may be purified from the lead, of which it commonly has some admixture, by injecting sulphur upon it in fusion ; for the lead is absorbed by the sulphur, and forms with it a concrete, which floats unmelted on the surface, and may be easily skimmed off. *Lewis.*

strongest attraction to gold and copper, and this last metal acquires a yellow colour by it; which has occasioned many experiments to be made to produce new metallic compositions [e].

- f. It is dissolved by all the acids: of these the vitriolic acid has the strongest attraction to it; yet it does not dissolve it, if it be not previously diluted with much water. The abundance of phlogiston in this semi-metal is perhaps the reason of its strong attraction to the vitriolic acid.
- g. Quicksilver amalgamates more easily with zinc than with copper, by which means it is separated from compositions made with copper.
- h. It seems to become electrical by friction, and then its smaller particles are attracted by the loadstone; which effects are not yet perfectly investigated; but they may excite philosophers to make farther experiments, in order to discover whether the electrical power shews itself in the metals, by being attracted by the loadstone, or whether the magnetic power can be exerted on other metals than iron [f].

S E C T.

[e] The process for giving the yellow colour to copper, by the mixture of zinc, and of its ore called *Calamine*, has been described in Sect. 332. pag. 707. See also N^o 3. of the note to p. 672. *The Editor*.

[f] It has been said, already, in the note to p. 756. that no other metal besides iron, or in which some iron particles are contained, has any true attraction to the loadstone.

S E C T. 357. (Additional.)

Native Zinc.

Zinc has been found native, though rarely, in the form of thin and flexible filaments, of a grey colour, which were easily inflamed, when applied to a fire.

Bomare asserts to have seen many small pieces of native zinc among the calamine-mines in the Duchy of Limbourg, and in the zinc-mines at Goslar, where this semi-metal was always surrounded by a kind of ferrugineous yellow earth, or ochraceous substances; and adds, that he did not know any author who had mentioned the existence of this native zinc at Goslar.

Various mineralogists have entertained, indeed, their doubts, about native zinc; but this being a simple negative argument, cannot invalidate the positive assertion of such an eye-witness as Bomare. Besides, our own Author speaks very positively in the following Sect. 361. of zinc in a *metallic form*, mineralised by sulphur; and there is not the least contradiction, in admitting that it may be equally found alone without any mineralizer.

The Editor.

stone. Even pieces of bräs and other metals, which shew not the least attraction to the magnet, if they are hammered, or pounded in an iron mortar, or with an iron-pestle, or hammer, are found often to have acquired a magnetical power, although there be not the least visible particles of the iron attached to them. See however Sect. 389. and fol. *The Editor.*

D d d 3

S E C T.

S E C T. 358. (228.)

Zinc in a calciform state.

Zinc is found,

A. In form of calx, *Zincum calciforme naturale.*

1. Pure, *Minera zinci calciformis pura.*

a. Indurated, *Indurata.*

1. Solid.

2. Crystallised.

This is of a whitish grey colour, and its external appearance is like that of a lead spar; it cannot be described, but is easily known by an experienced eye. It looks very like an artificial glass of zinc, and is found among other calamines at Namur, and in England [*a*].

S E C T.

[*a*] The pure zinc-ore, according to Bergman, is mineralized by the *aerial acid*; and is generally distinguished by the name *vitreous*, on account of its similarity to the artificial glass of zinc; as the Author remarks in the text, it is sometimes hard enough to strike fire with hard steel, becomes yellow when roasted, effervesces, and dissolves almost intirely with acids, particularly the vitriolic and marine. Brunnich says, that this ore is sometimes found in the form of *flacitates*.

The English mines at Mendip hills contain a good deal of calamine; among several varieties, I got one in polyhedral crystals, as a very scarce one. The miners call it *Bony Calamine*.

J. R. Forster.

The

S E C T. 359. (Part of 228.)

Calamine.

2. Mixed, *Minera zinci calciformis impura.*
 2. With a martial ochre, *Ochra fve calx zinci martialis.*

1. Half indurated, *Ochra zinci indurata.*
 Calamine, *Lapis calaminaris* [a].

Whitish

The zinc spar is of a whitish, grey, bluish-grey, or yellowish colour, and of a hardness generally sufficient to strike fire with steel.

In its fracture it resembles *quartz*. It is amorphous, stalactitical, or crystallized in groups, and weighty.

By calcination it loses $\frac{1}{2}$ of its weight, without emitting any sulphureous or arsenical smell.

Is infusible in the strongest heat, either singly or with mineral alkali; but is fusible either with borax or microcosmic salt.

In the mineral acids it is soluble with effervescence: and, with the vitriolic, affords vitriol of zinc.

100 gr. of this ore contains about 65 of the calx of zinc, 28 of aerial acid, 6 of water, one of iron, and sometimes a little silica. *The Editor, from Kirwan, p. 313.*

[a] Calamine is of various colours, viz, white, grey, yellow, brown, or red. It is not so brittle as the tutenagore; but is of various degrees of hardness, though scarcely so hard as to strike fire with steel.

Its structure is either equable or cellular; and its form is either amorphous, or crystallized, or stalactitical.

When calcined it loses no part of its weight, except it be mixed with charcoal, and then flowers of zinc sub-
 l. i. e.

It is soluble in acids; and, with the vitriolic, affords vitriol of iron as well as of zinc; which shews that the iron it contains is not much dephlogiticated.

- a. Whitish yellow, from Tarnovitz in Silesia, England, and Aix-la-Chapelle.
- b. Reddish brown, from Poland and Namur.

This seems to be a mouldered or weathered blende.

- 2. b. With a martial clay or bole, from Hollberget in Norberke, in Westmanland. Sect. 135. (86.) d.
- c. With a lead ore and iron, England.

The specific gravity of the best sort, that is the grey, is $\approx 5,000$. 100 parts of this afforded to Bergman 84 of *calx* of zinc, 3 of iron, 1 of *argill*, and 12 of *flex*. But in other specimens, these proportions are very different. A good ore should afford at least 30 *per cent*; and its specific gravity should be about 4,400, or 5,000.

Some of these ores are not so poor as not to contain above 4 *per cent*. of *calx* of zinc.

Calamines contain sometimes a mixture of calcareous earth and lead. Most of the English calamines contain lead. Kirwan, p. 315.

The *Tutenago-ore*, brought from China, and analysed by Engestrom, is an ore of zinc, in which a notable proportion of iron is contained. It was of a white colour, interspersed with red streaks of *calx* of iron, and so brittle as to be easily broken betwixt the fingers. It did not lose weight by being roasted; was soluble in the mineral acids, particularly with the assistance of heat; and, with the vitriolic, afforded vitriol both of zinc and of iron. The quantity of fixed air was so small as to be absorbed by the solution. It contained from 60 to 90 *per cent*. of zinc: the remainder was iron, and a small proportion of *argill*. Biddheim discovered also this variety of zinc-ore in Germany; which contained also a little iron and some *flex*. *The Editor from Kirwan*, p. 314.

S E C T. 360. (Additional.)

Zeolytiform Zinc-ore.

The real contents of this substance were first discovered by Pelletier, a most accurate Parisian chymist.

It was long taken for a zeolite, being of a pearl-colour, crystallised, and semi-transparent.

It consisted of laminæ, diverging from different centers :

And becoming gelatinous with acids.

It was commonly called *Zeolyte of Friburgh*.

And contains 48 to 52 *per cent.* of quartz, 36 of calx of zinc, and 8 or 12 of water. Ed. from Kirwan, p. 318.

S E C T. 361. (229.)

*Zincum Mineralisatum.***B.** Mineralised zink,

1. With sulphurated iron, *Zincum ferro sulphurato mineralisatum*. Blende, Mock-lead, Black jack, Mock ore: the *Pseudo-galena* and *Blende* of the Germans [a].

Mineralised

[a] According to Mongez, the pseudo galena is sometimes semi-transparent, and crystallised; and almost always intermixed;

a. Mineralised zinc in a metallic form, *Zincum formâ metallicâ sulphuratum*. Zink ore.

This is of a metallic blueish grey colour, neither perfectly clear as a potter's ore, nor so dark as the Swedish iron ores [b].

1. Of a fine cubical or scaly texture, from China, Kongberg, and Jarlsberg in Norway.

2. Steel-grained, from Bowallen and Skien-shyttan, in the parish of Tuna, in Dalarna.

intermixed with *silver, lead, copper, arsenic*, and other metals, as well as with argillaceous and calcareous earth. But, as Bergman observes, the *zinc, iron, and sulphur*, are the only necessary ingredients for the formation of this ore.

[b] The principal varieties of *blende*, or *pseudo-galena*, are,

1. The Scaly form, and that composed of small cubes, similar to the *galena*. It is of a dark grey colour, and sometimes strikes fire with hard steel.

2. The scaly greenish-black coloured ore, resembling pitch, called *Pechblende* by the Germans. See the following Section.

3. The *red* coloured, which produces a reddish powder when scraped with a knife, and turns yellowish by calcination.

4. The phosphoric, or sparkling blend, to be mentioned in Note to Sect. 362. which is of a yellowish colour, or opaque, or semi-transparent; and, on being rubbed with a pen, in a dark place, it produces luminous sparks of a yellowish light. From Mongez.

5. And the *red*, phosphorescent when rubbed, which is found at Scharfenberg in Misnia, as Brunnich asserts. *The Editor*.

In all probability this ore is the *glanz blende* of Sect. 363. where its full description may be seen. *The Editor*.

S E C T. 362. (230.)

Zinc Pseudo-galena.

- b.* In form of calx, *Zincum calciforme cum ferro sulphuratum*. Blende. Mocklead, *Sterile nigrum*. *Pseudogalena*. This is found, [*a*]
 1. With coarse scales,
a. Yellow, semi-transparent, from Scharffenberg in Misnia, Schemnitz and Kongsberg [*b*].
b. Greenish, from Kongsberg.

Black,

[*a*] There are several varieties of *Pseudo-galena*, or *Black Jack*. They are in general of a lamellar, or scaly texture, and frequently of a quadrangular form, resembling *galena*. They all lose much of their weight when heated, and burn with a blue flame; but their specific gravity is considerably inferior to that of true *galena*. Almost all contain a mixture of lead-ore. Most of them exhale a sulphureous smell, when scraped; or at least when vitriolic or marine acid is dropped on them. *The Editor from Kirwan*, p. 319.

[*b*] This ore is as yellow as wax; is semi-transparent, and contains much sulphur.

In the dry way zinc is reduced from this ore, by distilling it, after torrefaction, with a mixture of its own weight of charcoal, in an earthen retort well luted, in a strong heat: but, by this method, scarce half of the zinc it contains is obtained. Kirwan, p. 323.

Another greyish yellow blende is found also, that consists of a mixture of blende, galena, and petrol.

It contains about 24 *per cent.* of zinc, and is probably the same as the grey blende mentioned by Monnet. Kirwan, p. 323.

This

- c. Black, *Pechblende* or *Pitch Blende* of the Germans, from Salberg and Falun in Sweden, and from Saxony.
- d. Blackish brown, from Storfallsberget in Tuna in Dalarne [c].
 - 2. With fine scales [d],
- a. White, from Silfberget in the parish of Rettwik in Dalarne.
- b. Whitish yellow, from Rettwik.

Reddish

[c] This ore is of a black colour, and of a moderate hardness.

It does not give fire with steel.

Is frequently crystallized; and

Is then sometimes transparent, or semi-pellucid:

When pulverized it affords a reddish powder.

If heated it decrepitates: emits a sulphureous smell, if laid on burning coals: and deposits white and yellow flowers.

It is not magnetic, even after torrefaction, but loses 25 per cent of its weight.

It is frequently mixed with silver, arsenic, and other metals.

100 parts of this ore, from Danemora, being examined by Bergman, exhibited 45 of zinc; 1 of regulus of arsenic; 9 of iron; 6 of lead, all slightly dephlogisticated; 29 of sulphur; 6 of water; and 4 of silver. *Kirwan*, p. 321.

[d] The crystallized blendes deserve to be mentioned in this place:

a. Dark red, very scarce; found in a mine near Freyberg. Something like it is found at the Morgenstern and Himmelsfurste.

b. Brown. In Hungary and Transilvania.

c. Black. Hungary.

These last varieties may easily be mistaken for tin-crystals; but, by experience, they may be distinguished on account of their lamellated texture and greater softness.

Their transparency arises from a very small portion of iron in them. *Brunnich*.

The

- c. Reddish brown, from Salberg, Silfverberget, and Hellefors in Westmanland [c].
 3. Fine and sparkling; at Goslar called *Braun Bleyertz* [f].

Dark

[x] The texture of this ore is generally scaly: sometimes crystallized and semi-transparent.

It gives fire with steel; but

Does not decrepitate, nor smoke when heated:

Yet it loses about 13 *per cent.* of its weight by torrefaction.

One *hundred* parts of this ore, from Sahlberg, contained (by Bergman's analysis) 44 of zinc, 5 of iron, 17 of sulphur, 5 of water, 5 of argill, and 24 of quartz. See the process for analysing this ore, in Kirwan, p. 322.

[f] There is a red blende, which becomes phosphorescent when rubbed. This is found at Scharfenberg in Misnia. *Brunnich.*

Another *Phosphorescent Blende* is generally greenish, yellowish-green, or red; and has different degrees of transparency; and is sometimes quite opaque.

When scraped with a knife in the dark, it emits light, even in water; and after undergoing a white heat, if it is distilled *per se*, a siliceous sublimate rises, which shows it contains the *sparry acid*, probably united to the metal, since it sublimes.

This ore is almost wholly soluble in the marine acid with a boiling heat.

Bergman found 100 *gr.* of this ore from Scharfenberg, to contain 64 of zinc; 5 of iron; 20 of sulphur: 4 of *fluor acid*; 6 of water; and 1 of silic. Edited from Kirwan, p. 323.

The zinc, in the last kind of blendes mentioned in this Section, is, as it were, in the form of a calx or glass, so that they are often transparent. On the contrary, in the zinc ore of Sect. 361. [a], it seems to be in a metallic form, or, like most other metals, mineralised with sulphur.

The sulphur, nevertheless, exists in the different kinds of blende, equally as in the zinc-ore: and this remarkable difference in their appearance must be accounted for from another principle than the quantity of zinc which they contain;

a. Dark Brown, from Rammelsberg in the Hartz, and Salberg in Westmanland.

tain; because the yellow and the white blendes are often found to be richer than the zinc-ores; but these last are, however, more profitably worked for the metal. Perhaps it is because the blend does not contain a sufficient quantity of the phlogiston of the sulphur, to prevent the calcination of the zinc.

It is no matter whether a calcined blende is called *calamine* or not, provided it has such properties, that it may be employed to the same purposes, and with the same effect as that calamine, which nature has freed from its sulphur, by its withering or decaying. This may be done with some kinds of blende; and Mr. Von-Swab has given evident and excellent proofs of it in Sweden; in so much that it would demonstrate a want of experience to insist that sulphur cannot be expelled by calcination, without destroying the zinc itself; and that flowers of zinc may be produced from zinc ores in a calcining heat, without addition of any phlogiston.

Mr. Justi, however avers, that he has found an ore of this quality, which in his Mineralogy he calls *Zinc-spat*; but there is great reason to doubt whether it really contains any zinc, until it is shewn whether the author added any phlogiston during the calcination, or reduced the zinc out of it; because, although the flowers of zinc may not always be perfectly well calcined, yet there is no instance of a natural zinc-ore being discovered, which by itself yields those flowers during calcination. And it requires, besides, a strong heat to produce these flowers from a perfect calx or glass of this semi-metal, either natural or artificial, though mixed with a phlogiston: for it could not have been a native zinc, since it resembled a spar, and such a one very likely is not to be found in nature. *The Author.*

S E C T. 363. (Additional.)

Glanz blende [a].

This ore has a metallic appearance.

Is of a bluish grey.

Its form is generally cubical or rhomboidal.

Is of a scaly or steel-grained texture.

It loses nearly one sixth of its weight by calcination; and after calcination it is more soluble in the mineral acids.

One hundred parts of this ore afforded to Bergman about 52 of zinc; 8 of iron; 4 of copper; 26 of sulphur; 6 of silex, and 4 of water. *Kirwan.*

[a] To analyse this ore in the *moist way*; Bergman first expelled the water and part of the sulphur by distillation. The residuum he treated with 3 times its weight of oil of vitriol, carrying the evaporation to dryness; this he lixiviated with warm water, and found only 6 parts undissolved. In this solution a polished plate of iron was boiled, which precipitated the copper. He then, by means of the phlogisticated alkali, precipitated the zinc and iron. The precipitate being calcined in an open fire, was several times treated with nitrous acid, and evaporated to dryness, until the iron was perfectly dephlogisticated; fresh nitrous acid being then added, dissolved the zinc only, which being precipitated by the Prussian alkali, the proportion of zinc was found in its metallic state.

Neither metal contained in this ore is much dephlogisticated. See the process properly described by Kirwan, as p. 317 and following. The Editor.

S E C T.

S E C T. 364. (122-3)

Zinc mineralised by the vitriolic acid.

This ore has been already described in Sect. 210. and in the notes p. 411.

S E C T. 365. (231.)

Observations on Zinc [a].

It appears from old coins, and other antiquities, that the making of brass was known
in

[a] 1. Zinc is also called by Neumann and various other authors by the names of *Tutenago*, *Spjauter*, *Contrefait*, and *Spelter*. The Dutch bring to Europe, in the *East India* ships, a great quantity of *tutenago*, which is a little *bluer* than the German zinc, and also more tenacious. But we know nothing certain (says Cramer), either of the country where the ore that contains this zinc is found, and much less of the manner in which this semi-metal is obtained from it: for it is asserted that no European is granted the liberty of entering into the Chinese manufactories.

2. We have obtained, however, since the time of Cramer, some knowledge respecting the contents in the Chinese *tutenago* ore, as appears by the last note to Sect. 359. pag. 776.

3. As to the German zinc, it is well known, that it is not extracted from any ore by eliquation, as other metals and semi-metals are melted out from theirs; and in fact all the zinc that is there prepared is obtained by sublimation, not
from

in the most antient times; and that it was their *Æs Corinthiacum*, which contained copper and zinc. But it is not long since this semi-metal was discovered to lie concealed in calamine, and that calamine was its peculiar ore, and also a body of distinct qualities, prepared by nature, equal to that which is got tolerably pure at the furnaces of Goslar, or that is imported from China, under the name of *tutenago*.

Mr.

from any singular ore, but out of an intricate and confused mixture of different ores, some of which contain zinc; at the same time that several other metals, and semi-metals, are separated from the same, such as iron, lead, and copper, which are almost all combined with sulphur, and arsenic.

3. And moreover no peculiar sublimation is there employed for the extraction of that zinc, it being only by a secondary operation, that the volatile fumes of zinc are collected at the same time, during the eliquation of the other metals, especially of lead. It may be easily conceived by the description given by Cramer of the smelting furnaces of Goslar, that it must have been merely chance without design that the upper channel was applied within them, by which a very small part of the volatilized zinc, is preserved and reduced into its reguline form; so that out of the vast quantity of ores smelted there which, within the space of 18 hours, is more than 60,000 weight, hardly 3, or at most 5, pounds of zinc are obtained.

4. Pott, on his *Essay on Zinc*, says, that our countryman, Dr. Isaac Lawson, of whose great knowledge in mineral chemistry he speaks very respectfully, really obtained some small quantity of regulus of zinc from calamine; and makes several quotations from a Dissertation published by the same Dr. Lawson, upon the *nihil*, or *flowers of zinc*. Dr. Campbell likewise asserts positively, in his *Survey of Great Britain*, that Dr. Lawson discovered calamine to be the true mine of this semi-metal. In all probability this was the same learned gentleman, by whom Cramer had been employed in England,

E c c

land,

Mr. Brandt removed a great many doubts about the origin of zinc, and the metallic earth of the calamine, by having in the year 1734, a favourable opportunity of examining the calamines, and different kinds of blends, from Rettwik in Dalarne. He then proved, in his *History of the Semi-metals*, that blends and calamines are ores of zinc; and that the *Galitzenstein* (Sect. 210 of this Edit.) of the Germans was its vitriol.

Soon

land, as his Operator in chemistry. He resided a long time afterwards at Leyden, living in great intimacy with *Borhaave*, *Vanswieten*, *Gaubius*, *Grenovius*, and with several other men of great learning in that flourishing University, and went at last to Flanders, where he died in the year 1745. It is to his care and trouble of reducing into order, and writing for the press, the *course of lectures and experiments*, given at Leyden in 1735, to a society of gentlemen, most distinguished for their skill in all branches of natural philosophy, that the world is indebted for that excellent work, intitled *Elements of Essaying Minerals*, by *J. A. Cramer*. This last gentleman did collect, indeed, the chief part of the materials; but they would probably have remained buried in oblivion, without the assiduous labour and industrious care and intelligence of Dr. Lawton, as may be seen by the advertisement prefixed by Dr. C. Mortimer to the second edition of that work.

5. It deserves notice, however, that, although Dr. Lawton was acquainted with the method of smelting zinc from calamine, he never gave the least hint of the process in the said work of Cramer. Perhaps he was in hopes of publishing it afterwards at large, in a compleat work on the subject, from which performance he was unhappily prevented by his untimely death. It is proved, beyond all controversy, by the arguments and authorities adduced by Dr. Watson, in the second Essay of his fourth volume, that the ancients, and particularly the Romans, formed their *orichalcum*, as we do our *brass*, by melting copper with calamine, &c. This operation

Soon after, the bluish-grey zinc-ore was discovered by Mr. Von Swab at Bowallen, who, in the year 1738, prepared calamine from it, and erected a work for distilling zinc at large from it, at Westerwiken in Dalarne; which manufacture, however, afterwards was laid aside for other intervening business.

Thus these first discoverers might perhaps have given to Messieurs Pot and Margraff, the opportunity

operation has been fully described in the note [g] to Sect. 332. p. 707. But it was reserved for modern metallurgists to discover, that this phenomenon is produced by a volatile substance, which can assume a solid state or form, like any other semi-metal.

6. The two principal ores of zinc are now very well known to be *calamine* and *blende*. The name of the first is taken from the Arabic *climia* or *calamia*, which denotes, as Watfon asserts, the very same semi-metal; but, by the word *blende*, the Germans mean a *misleading* or *blinding* mineral; because, notwithstanding the great resemblance of *blende* to the *lead-ore*, on account of its shining particles, nevertheless it does not yield any lead at all. From thence *blende* is also called the *Pseudogalena*, and *Mock-lead*; and in fact many unexperienced smelters have been deceived by this great simillarity, buying *blende* for the true *galena*, which is called *Potter's lead ore* of Derbyshire. But in general *blende* is better known among our English miners by the nick name of *black-jack*; by whom it is disposed of to the makers of brass.

7. Calamine is found in many parts of Europe; and we have great plenty of it in *Somersetshire*, *Flintshire*, *Derbyshire*, and in many other parts of England. It is scarcely to be distinguished by its appearance from some sorts of *lime-stone*; for it has none of the metallic lustre usually appertaining to ores, and only differs by its specific gravity, it being near twice as heavy as *flint* or *lime-stone*.

8. The first dressing of the calamine consists in picking out all the pieces of *lead-ore*, *lime*, and *iron-stone*, *cauk*, and

E e e 2

other

opportunity to make the history of zinc more known to the world: the former in his *Treatise de Pseudogalena* in the year 1741; and the latter, in the *Memoirs* of the Academy of Berlin: though this notice is by no means intended to deprive these ingenious gentlemen of the honour they merit, for having had of themselves the same opinion, and proposing the same experiments.

The

other heterogeneous substances, which are found mixed with it in the mine: it is then calcined in proper furnaces, where it loses about a fourth or third part of its weight. It is picked out again very carefully, as the heterogeneous particles have become more discernible, by the action of the fire; it is then ground to a fine powder, and washed in a gentle rill of water, which carries off the earthy mixtures of extraneous matters; so that, by these processes, a *ton* weight of the crude calamine of Derbyshire is reduced to *twelve hundred* only.

9. As to the *blendes* or *black-jack*, they vary very much in their external appearances and internal constitutions, as was described in the preceding sections. In general, the *blendes* contain *zinc* and *sulphur* united together by the intervention of *iron*, or of *calcareous earth*; and must be previously freed of the *sulphur* by means of calcination, to produce *zinc*.

Bergman asserts that a certain Englishman made, several years ago, a voyage to China; for the purpose of learning the art of smelting *zinc*, or *tutenago*; but though he became instructed in the secret, and returned safely home, he carefully concealed it.

10. The manufactory of *zinc* was, however, established in England about the year 1743, when Mr. Champion obtained a patent for the making of it, and built the first work of the kind near Bristol. It consists, as Watson relates, of a circular kind of oven, like a glass-house furnace, in which were placed 6 pots, of about 4 feet each in height, much resembling large oil-jars in shape, into the bottom of each

The zinc from Ramelsberg in the Hartz, is like most of the lead and copper ores from the same mines of a very fine grained texture, which we call *Steel-compact*; and is likewise so often equally mixed with the said copper and lead ores, as not to be so easily perceived, if one is not previously acquainted with them. It seems, nevertheless, reasonable that a true mineralist ought rather to suspect the ore called
Brown

each pot is inserted an iron tube, which passes through the floor of the furnace, into a vessel of water. A mixture of the prepared ore, as mentioned above N^o 8 and 9, is made with charcoal, and the pots are filled with it to the mouth, which are then close stopped with strong covers, and luted with clay. The fire being properly applied, the metallic vapour of the calamine issues downwards, or *per descensum*, through the iron tubes, there being no other place through which it can escape; and the air being excluded, it does not take fire, but is condensed in the water into granulated particles; which being remelted, are cast into ingots, and sent to Birmingham under the name of zinc or *spelter*; although by this last name of *spelter*, only a granulated kind of soft brass is understood among the braisers, and others who work in London, used to solder pieces of brass together.

11. Great part of the zinc volatilized, by the force of fire in large furnaces, as those at Goslar, adheres to their sides in the form of a whitish calx; this is scraped off, when the furnace is cold, and is called by the name of *Ilsenbruch*, or *Cadmia fornacum*, which is employed, as well as zinc, to make brass.

12. Another substance, common in the shops, is called *Tutia*, or *Tutbia*, according to Lemery. This seems to be some preparation of the calx of zinc with other matters, and varies very much in its contents, as well as external appearances: it changes, or ought to change; copper also into brass; and is employed in the composition of some unguents by the apothecaries, although the effects must vary, according to the integrant parts of this compound.

Brown Bleyertz (Sect 362-3) to be a zinc-ore, than to suppose this semi-metal to be a product of lead, copper, and iron.

S E C T. 366. (232.)

4. Antimony. *Antimonium. Stibium.*

Its general properties [a].

This semi-metal is,

a. Of a white colour almost like silver.

Brittle:

13. The *Pompholix, Diphryges, Nihil, Nihil album, Sponium Græcorum, Cadmia botrites, Zonites, Onychites, Ostracites, Placites, Capnites*, &c. mentioned by medicinal and metallurgical writers, are productions of zinc, with various external appearances of colour, and consistence or form, which differ very little, or perhaps nothing at all, from themselves in their properties; but are cherished by whimsical authors on account of the singularity of their names. *The Editor from Neumann, Watson, &c.*

[a] The colour of antimony, in its reguline form, is of a silver white; its texture appears micaceous; and is remarkably brittle.

Its specific gravity, when perfectly freed from iron, is = 6,860.

The *nitrous acid* dephlogisticates antimony; but holds only a very minute portion of it in solution.

The *vitriolic acid*, if boiling, dissolves antimony; but the *muritic* and *aceticus* acids act hardly at all upon it, unless previously calcined.

Aqua regia formed of 7 parts of *marine* and one *nitrous acid*, dissolves this semi-metal in a considerable degree.

It is also soluble in a mixture of the *vitriolic* and *maric* acids, or even of the *vitriolic* and *nitrous* acids.

- b.* Brittle; and in its texture, it consists of shining planes, of greater length than breadth.
- c.* In the fire it is volatile, and volatilises part of the other metals along with it, except gold and platina. It may, however, in a moderate fire, be calcined into a light grey calx, which is pretty refractory in the fire, but melts at last to a glass of a reddish brown colour.
- d.* It dissolves in spirit of sea-salt and *aqua regia*, but is only corroded by the spirit of nitre into a white calx; it is precipitated out of the *aqua regia* by water.

It

The phlogiston it loses by solution, is expressed by 120; and in respect to the force wherewith it retains this, it stands in the *sixth* place.

It melts in the fire long after it becomes *red hot*, viz. at the 809 *degree*; provided it be in its pure reguline form; otherwise it melts at the flame of a candle. When melted, it emits a white smoke, and evaporates, forming itself into white and refractory flowers, as the author remarks. See the N^o 10 of the note to Sect. 372.

In close vessels it sublimes without decomposition. *Bergman, Kirwan, &c.*

Crude antimony soils the fingers, when handled.

It is found in different parts of Europe, as Bohemia, Saxony, Transylvania, Hungary, Sweden, Spain and France, &c. it commonly lies alone in mines, intermixed with earthy or stony matters.

Sometimes it is blended with the richer ores of silver, and renders the extraction of that metal very difficult; for the antimony volatilizes a part of the silver, or *robbs the ore*, as the miners express themselves.

It is separated from its natural impurities by fusion, in an earthen pot, whose bottom is perforated with a number of

Pl. c. 4

holes;

- e. It has an emetic quality when its calx, glass, or metal, is dissolved in an acid, except when in the spirit of nitre, which deprives it of this effect.
- f. It amalgamates with quicksilver, if the regulus when fused, be added to it; but the quicksilver ought for this purpose to be covered with warm water: it amalgamates with it likewise, if the regulus of antimony be previously melted with an addition of lime,

holes; it is then surrounded by burning coals: the fluid antimony passes through the holes, whilst the unfusible matters remain behind. This melting vessel must have been let into the mouth of another pot, sunk in the ground, which serves as a receiver, in this kind of melting *per descensum*. The juncture of the two vessels must be closely luted; and several sets of this apparatus are generally worked at once. See the last N^o of the note to Sect. 369.

In the purification of gold, when it contains other metals, antimony is employed. See the N^o 8 of the note to Sect. 372.

The *flowers of antimony*, already mentioned, are nothing else but its pure calx; and, if put in a proper degree of fire, in a close crucible, produce a brownish red glass of a deep hyacinthine colour. See N^o 12 of the Note to Sect. 372.

If antimony is melted in a close crucible, and is cooled gradually, it assumes the form of insulated pyramids, and sometimes of a regular form of stars.

This semi-metal combines very well with sulphur.

Crude antimony being projected in a crucible, in which an equal quantity of nitre is fused, detopates; is calcined, and forms a compound, called by the French, *Fondant de Retoux*, or *Antimoine Diaphoretique non lavé*. This being dissolved in hot water, falls to the bottom after it is cold; and after decantation, is known, when dry, by the name of *Diaphoretic Antimony*. *Mongez*. See the note to Sect. 372, N^o 20.

SECT.

S E C T. 367. (233.)

Native Antimony.

Antimony is found in the earth.

A. Native, *Antimonium nativum*, five, *Regulus Antimonii nativus*.

This is of a silver colour, and its texture is composed of pretty large shining planes.

This kind was found in Carls Ort, in the mine of Salberg, about the end of the last century [6], and specimens thereof have been preserved

[6] Since native antimony, or, as it is commonly called, *regulus of antimony*, was never before known, the possibility of its existence has been denied; and when the specimen here mentioned, was discovered, a certain person published his doubts of the truth of the whole affair, upon no better foundation than that the specimens were very small for making experiments, and that it was uncertain if ever mineralised antimony had been found in the mine of Salberg.

But those reasons are not sufficient to refute experiments, because men of experience are always able to make true experiments on small pieces of native metal; nor is there any necessity that mineralised metals should always be found along with the native ores of the same species; though this really happens with this antimony in the mine at Salberg.

We ought to be contented with conclusions drawn from experiments, until the fallaciousness of such experiments is demonstrated. And it were to be wished, that all pretended discoveries were supported by experiments, and an enumeration of the phenomena which happen in them; we should then not contradict things, which perhaps may be true, though, for want of this precaution, they seem scarce credible; as, for instance, the *native tin*, *lead*, and *iron*,
the

preserved in collections under the name of an arsenical pyrites, till the mine-master Mr. Von Swab discovered its real nature, in a treatise he communicated to the Royal Academy of Sciences at Stockholm, in the year 1748. Among other remarkable observations in this treatise, it is said, *first*, That this native antimony easily amalgamated with quicksilver; doubtless, because it was imbedded in a limestone; since, according to Mr. Pott's experiments, an artificial regulus of antimony may, by means of lime, be disposed to an amalgamation. *Secondly*, that it yielded crystals *in forma calcis*, during the cooling.

the *zink spar*, and an unknown semi-metal in the mica. *The Author.*

Counsellor Muller, in a letter of the 21st September 1782, inserted in *Journ. de Physique*, for July 1787, and directed to Baron de Born, pretends that the above ore of *native antimony*, acknowledged as such by Mr. Von Swab, was nothing but a true native bismuth. Mr. de Reprecht, however, wrote, on the 20th of October following, a full refutation of C. Muller's arguments, to the same Mr. de Born. This last letter was also inserted in the next article of the same *Journal de Physique*; and shews the power of old prejudices, in spite even of ocular demonstrations.

But Mr. de Reprecht, it seems, has recanted, *honourably*, if influenced only by the love of truth! See pag. 231- of the same Journal for September following.

It appears by the same letters, that *native antimony* is found also in different other ores, as those from *Fuzebay* and *Transylvania*; and that the *blackgold-ores* from *Nagyag*, contain not only *gold*, but also *silver*, *iron*, *lead*, *antimony*, *arsenic*, and *sulphur*, whose respective proportions, Mr. de Ruprecht, had undertaken to ascertain.

And lastly, Mr. Mongez above quoted, has given a full account of the *native antimony* found in the mines of *Allemond* in *Dauphiny* by Mr. Schreiber, some samples of which he examined by the *dry* and *humid way*, which he found to be alloyed with about 3 per cent. of *arsenic*. See the *Journal de Physique* for July 1783, p. 66. The Editor.

S E C T.

S E C T. 368. (Additional.)

Antimony Mineralized by the Aerial Acid.

This ore was lately discovered by Mongez, among those of *native antimony*, from the mine of *Chalanges* in *Dauphiny*.

It consists of a group of white crystalized filaments of a needle-form appearance, diverging from a common center, like zeolyte.

They are insoluble in nitrous acid; and,

On being urged by the flame of a blow-pipe, upon a piece of charcoal, they are diffipated into white fumes, or antimonial flowers, without any smell of arsenic; from whence it follows, that these needle-formed crystals are a pure *calx of Antimony*, formed by its combination with, or mineralized by, the aerial acid. See Kirwan, p. 325, and *Journal de Physique* for July 1787, p. 67.

S E C T. 369. (243.)

B. Mineralized Antimony.

1. With sulphur, *Antimonium sulphure mineralisatum*. *Antimonium proprie sic dictum* [c].

This is commonly of a radiated texture, composed of long wedge-like flakes or plates; it

[c] The mountains in Upper Hungary are all rich in these kinds of ore, especially in the county of *Liptaw*, whence it is exported to Poland. *Brunnich*.

it is nearly of a lead colour, and rough to the touch.

a. Of coarse fibres.

b. Of small fibres.

c. Steel-grained, from Saxony and Hungary.

d. Crystallised, from Hungary.

1. Of a prismical, or of a pointed pyramidal figure, in which last circumstance the points run to one center.

I have seen a specimen of this, in which the crystals were covered with very minute crystals of quartz, except at the extremities, where there was always a little hole. This specimen was given for a *flos ferri spar*.

The sulphureous ores of antimony are the most common, and the most productive of this semi metal.

The common *black-grey*, or *bluish antimony*, is most usually of a striated texture; yet there is some found without any determinate form, and in this case it may be easily mistaken for the *small-grained lead-ore*, or *white silver-ore*, or *iron-glimmer*; but the way to distinguish it immediately from these, is to hold only a piece of this ore in the burning flame of a candle; because the antimony will melt in that low heat, which none of the other ores does; an experienced eye may readily discover it by the colour.

Crude antimony is not only that which is separated and picked out in compact pieces from the stony or other heterogeneous matters of the ore; but also what is melted at first out of its mineral stones and earths, by fire. This ore has indeed its own regular veins like other minerals; and yet some other kinds of ores are sometimes found along with it. *Gellert's Metallurgy*, p. 59.

The texture of these ores is not only *fibrous*, and often *inclined* to a common centre, but also *cuneiform*, *striated*, *solid*, and *lamellated*: these last are sometimes called *Antimonid*

nial Galenas. They are also found sometimes in a *plumose form*, consisting of extremely delicate fibres, like feathers.

As to colour, they are not only *dark* or blueish-grey, but sometimes they show, in their needle-form masses, the finest *purple*, variegated with shades of *red*, *blue*, *green*, *yellow*, and *whitish-grey*, like the pigeon's neck.

Wallerius and Bomare describe other varieties of these antimonial ores, which differ by colour or shape; but it will be sufficient to indicate only their descriptive Latin epithets, viz.

Striatum colore griseo.

Fibrosum plumbo-simile.

Fibris parallelis.

Striis inordinatis.

Striis decussantibus.

Striis intercussantibus.

Striis ex centro divergentibus.

Striis concentricis.

Striis stellatis.

Striis in plana nitida concretis.

Striato-squamosum.

Lanae instar, fibris capillaribus separatis.

Plumosum, { *album.*
rubrum.
flavescent.
viride.
cærulescens.

Textura Chalybea.

Crystallisatum, { *figura incerta*
fig. turrita seu
pyramidalis.
tuberosa.
nodosa.
drusica.

Griseum speculare, cinereum, &c.

The specific gravity of antimony is for the most part from 4 to 4200; and, when melted, from 4700 to 500. But if the regulus be well depurated from sulphur and iron, its specific gravity is much greater, as was mentioned in the note [a] to Sect. 366.

This ore of antimony soils the fingers when handled, and is very brittle.

When

S E C T. 370. (235.)

Red-Antimony Ore.

2. With sulphur and arsenic, *Antimonium auripigmento mineralisatum*. Red antimony ore, *Antimonium solare*.

This is of a red colour, and has the same texture with the preceding, though its fibres are not so coarse.

a. With small fibres.

b. With abrupt broken fibres, from Braunsdorff in Saxony, and from Hungary [d].

All

When gradually heated in a crucible, it loses about 22 per cent. of its weight; and becomes a grey calx.

It is perfectly soluble in the *marine acid*, with the assistance of heat.

The *nitrous* only calcines the reguline part.

100 parts of this ore contain 74 of the *antimonial regulus*, slightly dephlogisticated, and 26 of *fulphur*.

It is analysed by solution in *aqua regia*, consisting of 1 part of *nitrous*, and 4 parts of *marine acid*. The sulphur is found in the filter; for this solvent only acts on the semi-metal, and the sulphur being disengaged, floats over the solution.

In the *dry way* antimony is separated from the stony parts of its ore by distillation *per descensum*. It is afterwards reduced to a regulus by gently roasting it, until it loses 22,5 per cent. of its weight; and then mixing the grey calx thus formed, with twice its weight of *black flux*, and briskly fusing it in a covered crucible, the regulus is obtained. *The Editor from Kirwan p. 326, and Mongez, &c.*

[a] In Hungary nobody knows this kind of ore. I only found it at Braunsdorff: therefore some, who have not seen it, deny its existence. *Beynisch.*

The

All antimonial ores are somewhat arsenical, but this is more so than the preceding kinds.

S E C T. 371. (236.)

Mineralized with other metals.

C. With sulphurated silver. The *plumose silver ore* of Sect. 274 [e].

With

The red-colour of this ore proceeds from the mixture of arsenic. Wallerius speaks of 3 varieties of this ore, that are found in Hungary and Saxony, viz. 1. of a red colour; 2. of *purplish* or *violet*; and 3. of a *pale red* colour. See the Spec. 396 of Wallerius's System. Mineral.

Bomare describes also the following arsenical ores of antimony, which, in all probability, are the same mentioned by Wallerius after himself, viz.

1. The *red* with parallel fibres, *striis fere parallelis*, found at *Braunsdorff* in Saxony.

2. The *pale-red*, or of a *violaceous* colour, found at *Presbourg* in Hungary, and another of a *blue* colour found also at *Braunsdorff*.

3. The *red* with the fibres disposed in a starry form, found in Hungary and Saxony.

4. The *purple red*, which is *plumose*, or of very thin silky fibres, like *hair*, or *wool*: and sometimes in a *dendritical* form, upon the white quartz of the grey ore of antimony, in the mine called the *Old-Hope of God* in *Freyberg*.

5. And the *plumose ore* of an *ash* colour, which is also found of a *purple-red* colour, at *Braunsdorff* in Saxony.

Finally, the same author speaks of a *horn-antimony*, *minera antimonii cornea*, which is said to have been found at *Stolberg*.

[e] Besides the colours of this ore mentioned in Sect. 274, there are also ores of the kind, which are *red* or *green*: and then they contain but a small proportion of silver. Their texture is filamentous, very brittle and fusible.

These

D. With sulphurated silver, copper, and arsenic. See Sect. 276 [f].

E. With sulphurated lead. See Sect. 314.

These ores may be analysed by solution in *aqua regia*: both the regulus of antimony and the arsenic remain in the solution, and the sulphur is separated by filtration. If the solution be then boiled with twice its weight of strong *nitrous acid*, the regulus of antimony will be precipitated on account of its dephlogistication; and, the arsenic which is then converted into an acid, will remain in the liquor, and may be procured by evaporation into dryness.

[f] If *silver* or *copper* be suspected in the scorix, they may be analysed by boiling in about 6 times their weight of *dilute nitrous acid*, which will take up the silver and copper, and leave the regulus of antimony and the arsenic.

These last may be boiled in *strong nitrous acid*, which dephlogisticates the antimony, and the arsenic becomes soluble in water: so that the calx of antimony remains undissolved. The sulphur may be found in a second experiment, using *aqua regia* instead of the concentrated *nitrous acid*, and the silver may be precipitated with a clean plate of copper, previously weighed; for in this case, the silver precipitates upon it in its metallic form, which may be weighed, and its contents known. As to the copper, it may be precipitated by aerated mineral alkali; and 194 gr. of this precipitate well dried are equivalent to 100 gr. of copper in its metallic form. But from this last, the weight lost by the copper plate, during the operation, must be subtracted.

N. B. If in this solution by *aqua regia*, the precipitation of the silver should be attempted by the *marine acid*, it would unite to the copper, and form a triple salt, which would also be precipitated together.

If the residuum should casually contain *sulphur*, *arsenic*, and *iron*; by boiling it in the spirit of salt, the arsenic and iron will be taken up: the first (the arsenic), may then be precipitated by the addition of water, and the iron by the Prussian alkali, &c. *The Editor from Kirwan, p. 327, 248 and 250.*

SECT.

S E C T. 372. (237.)

OBSERVATIONS ON ANTIMONY [a].

By the name of Antimony is commonly understood the crude antimony, (which is compounded

[a] .1. Though the regulus of antimony is a metallic substance, of a considerably *bright white colour*, and has the *splendor, opacity, and gravity* of a metal; yet it is quite *unmalleable*, and falls into powder, instead of yielding or expanding under the hammer; on which account it is classed among the *semi-metals*.

2. Dr. Lewis mentions an easy process to give a most brilliant metallic appearance to the regulus of this semi-metal. It consists in throwing a lump of *cauk* (or *terra ponderosa*) into the crucible, in which the antimony is melted in the fire; about one or two ounces of the *cauk* red hot will suffice for about 16 ounces of the melted semi-metal: and the fusion being continued about two minutes more, on pouring it off, there will be found about 15 ounces of the regulus, as brilliant as *polished steel*, or *pure quicksilver*.

3. Regulus of antimony is used in various metallic mixtures, as for *printing types, metallic speculums, &c.* It enters into the best sort of *printer ware*.

4. It mixes with, and dissolves various metals; in particular it affects iron the most powerfully; and, what is very remarkable, when mixed together, the iron is prevented from being attracted by the *load-stone*, as was mentioned in the note, N^o 38, to p. 756.

5. It affects copper next, then *tin, Lead, and silver*; promoting their fusion, and rendering them all brittle and unmalleable; but will neither unite with *gold*, nor *mercury*; though it may be made to combine with this last by the interposition of

compounded of the metallic part and sulphur) as it is melted out of the ore (Sect. 369.): and by the name of regulus, the pure semi-metal.

The

sulphur. In this case it resembles the common *Æthiops*, and is thence called *Antimonial Æthiops*.

6. *Regulus* of antimony readily unites with sulphur, and forms a compound of a very faint metallic splendor: it assumes the form of long needles adhering together laterally: it is usually formed naturally also in this shape. This is called *Crude Antimony*.

7. But though antimony has a considerable affinity to sulphur; yet all the metals, except *gold* and *mercury*, have a greater affinity to that compound. If therefore *iron*, *copper*, *lead*, *silver*, or *tin*, be melted with antimony, the sulphur will unite with the metal, and be separated from the regulus, which, however, takes up some part of the metal, for which reason it is called *Martial Regulus*, *Regulus Veneris*, &c.

8. When gold is mixed, or debased by the mixture of other metals, it may be fused with antimony; for the sulphur combines with the base metals, which, being the lighter, rise up into scoria, while the regulus remains united at the bottom with the gold; which being urged by a stronger degree of heat, is freed from the semi-metal, which is very volatil. This method of *refining gold* is the easiest of all. See note [g], to p. 518.

9. But the most numerous purposes, to which this semi-metal has been applied, are those of the chemical and pharmaceutical preparations. Lemery, in his *Treatise on Antimony*, describes no less than 200 *processes* and *formulae*; among which there are many good, and many useless ones. The following processes deserve to be mentioned on account of their utility.

10. Antimony melts as soon as it is moderately red hot, but cannot sustain a violent degree of fire, as it is thereby dissipated into smoke and white vapours, which adhere to such cold bodies as they meet with, and are collected into a kind of *fatina* or powder, called *Flowers of Antimony*.

11. If

The alchemists have made great use of antimony in their experiments; some of them chiefly on account of its being found in the Hungarian gold mines. Yet still we know no more of

11. If it be only moderately heated, in very small pieces, so as not to melt; it becomes calcined into a greyish powder destitute of all splendor, called *Calx of Antimony*. This calx is capable of enduring the most violent fire; but at last it will run into a *glass* of a *reddish yellow colour*, similar to that of the *Hyacinth*. The longer the calcination be continued, the more refractory it will be, and the less coloured the glass will become. The calcination of antimony may even be carried so far, that it will not vitrify, unless a small portion of crude antimony be thrown into the crucible.

12. The following is the best method for avoiding disappointment and perplexity in making this antimonial glass. Take any quantity of calx of antimony, made without addition, put it into a good crucible, which set in a melting furnace; kindle the fire gradually, and leave the crucible uncovered at the beginning; a quarter of an hour after the matter is red-hot, cover the crucible, and excite the fire vigorously, till the calx melts, which may be known by dipping into the crucible an iron wire, to the end of which a little knob of glass will adhere, if the matter be in perfect fusion. Keep it so for a quarter of an hour, or rather longer, if the crucible can bear it; then take it out, and pour the melted matter on a smooth stone, made hot for the purpose, or in a proper mould to give it the form of a cup, or of pills, called *Pilulæ Perpetuæ*.

The infusion made of this coloured antimonial glass, in acidulous wine (such as that of Bourdeaux) for the space of 5 or 6 hours, is a very violent emetic.

13. If equal parts of *nitre* and *regulus of antimony* be deflagrated over the fire, the grey calx which remains is called *Liver of Antimony*.

14. If *regulus of antimony* be melted with two parts of *fixed alkali*, a mass of a *reddish yellow* colour is produced, which being dissolved in water, and any acid being afterwards added, a pre-

of the constituent parts of this semi-metal than the others, notwithstanding all that has been written on the subject. Some say that

precipitate is formed of the same colour, called *Golden Sulphur of Antimony*.

15. Fixed nitre, *viz.* the alkaline salt that remains after the deflagration of nitre, being boiled with small pieces of regulus of antimony, the solution becomes reddish; and, on cooling, deposits the antimony in the form of a red powder called *Mineral Kermes*.

16. Equal parts of the *glass*, and of the *liver* of antimony, well pulverised and mixed with an equal quantity of pulverized *cream of tartar*, being put into as much water as will dissolve the cream of tartar, and boiled for 12 hours, adding now and then some hot water, to replace what is evaporated; the whole is to be filtered while hot; then being evaporated to dryness, the saline matter that remains, is the *emetic tartar*.

17. The regulus of antimony being pulverised, and distilled with *corrosive sublimate of mercury*, a thick white matter is produced, which is extremely corrosive, and is called *Butter of Antimony*. This thick substance may be rendered limpid and fluid by repeated distillations.

On mixing the *nitrous acid* with this *Butter of Antimony*, a kind of *aqua regia* is distilled, called *Bezoardic Spirit of Nitre*.

18. The white matter that remains from this last distillation, may be redistilled with fresh nitrous acid; and the remainder being washed with water, is called *Bezoar mineral*, which is neither so volatile, nor so caustic as the *antimonial butter*. This butter being mixed with water, a precipitate falls to the bottom, which is very improperly called *mercurius vitæ*, for it is in fact a very violent emetic.

19. But if, instead of the *regulus*, *crude antimony* be employed, and the same operation be performed; the reguline part separates from the sulphur, unites to the mercury, and produces the substance which is called *Cinnabar of Antimony*.

20. The method of making *diaphoretic Antimony* has been already described in the note [a] to Sect. 366. p. 792. This pre-

that its earth is not vitrifiable, because it is volatile, which is perfectly contrary to experience: and if volatility be the characteristic of a mercurial earth, the pipe clay

preparation excites animal perspiration, and is a good *sudorific*. The very same preparation of the *diaphoretic antimony* may be more expeditiously made, by *one* part of *antimony* with *two and a half* of *nitre*, mixed together and deflagrated: the residue of which is the mere *calx of antimony*, void of all *emetic power*.

21. And if the detonation be performed in a tubulated retort, having a large receiver, containing some water, adapted to it, both a *cyffus* of antimony and the antimonial *flowers* may be obtained at the same time, as Neumann asserts.

22. When nitre is deflagrated with antimony over the fire, the alkaline basis of the nitre unites with the calx of the semi-metal, which may be separated by an acid, and is called *Materia Perlata*.

23. It is beyond any controversy that this semi-metal acts on the human body as a violent (and sometimes virulent) emetic, and as a strong cathartic, impregnating vegetable acids, as *vinegar* and *acid-wines*, with these virtues, almost inexhaustibly. By sulphur, and by calcination with nitre, its malignity is abated, and its emetic power changed into a diaphoretic one. But as soon as it is restored to its pure metallic state, it resumes its virulence, which may be again destroyed, and again restored, and almost infinitely varied.

24. Hoffman has given an account of the different medicinal and pernicious effects of antimony, as arising from its different modes of treatment. *Crude antimony*, on account of the *regulus*, being corrected by the *sulphur*, is not only safe, but in many cases a medicine of great service, both for the human species and other animals.

25. By simple fusion it acquires a degree of malignity; but a far greater one if melted with half its weight of nitre, which consumes nearly all the sulphur, and leaves the *regulus* bare.

26. Mixed with common salt, and calcined over a gentle fire for several hours, and afterwards edulcorated with water,

clay from Cologne ought to be of the same nature. Perhaps it is better to say that the calx of antimony is volatile, and may both

it yields an ash-coloured grey calx, which is so fixed as to bear a melting heat, and proves a mild and safe diaphoretic, void of any malignant or emetic quality.

27. In the same manner, if calcined with a gentle fire in an earthen vessel, uncovered and exposed to the open air, it changes into an innocent calx, without the least malignity. But if this very calx be melted with a strong fire into glass, it becomes so active, that a few grains will occasion violent vomiting and purging, or even mortal convulsions and inflammations.

28. Likewise, if the powdered regulus be calcined in a glass vial, over a sand heat, for several days, it becomes a greyish salutary diaphoretic powder. But, if reduced to regulus, by fusing it with powdered charcoal, nitre, and a little fat, it proves again virulent. Also, when antimony is melted with one fourth of its weight of salt of tartar, then powdered, the scoria separated, and the more ponderous matter pulverized, the reddish powder thus obtained is salutary; but when it is melted with three or four times its weight of salt of tartar, both the scoria and the regulus are virulent.

29. Equal parts of antimony and nitre, melted together, yield a virulent mass; but one part of antimony with 2 or 3 of nitre, makes an useful diaphoretic. The regulus melted with half its weight of nitre, continues emetic; but one part of regulus with two and a half of nitre becomes diaphoretic. Thus one preparation of antimony may be changed into another, a salutary into a poisonous, and a poisonous into a salutary one.

30. It is not yet ascertained, says Macquer, in which of the principles of antimony its *emetic virtue* resides. But it is evident, by what has been already asserted, that it cannot be ascribed to its earthy part; for the calx of antimony, when entirely deprived of all phlogiston, is not *emetic*, nor even *purgative*; as is evident from the effects of *diaphoretic antimony*, and the *pearly matter* of N° 22.

31. It is therefore equally evident, that this property of antimony depends upon the union of its metallic earth with
it.

be reduced into a metallic state with phlogiston alone, and melted into glass; and such is its nature, though we do not know the reason of it.

S E C T. 373. (238.)

Arsenic. *Arjenicum*, Lat.

General Properties of this Semi-metal.

5. Arsenic in its metallic form,

its phlogiston; and this appears to be the more probable; since by only re-combining phlogiston with the earth of this semi-metal, totally deprived by calcination of all its *emetic* *virtus*, this very virtue is perfectly restored, and the *regulus* thus revived is no less *emetic*, than that which never underwent calcination.

3a. After all that has been related in these notes, it is no wonder that antimony had been by many esteemed an effectual poison: and by others the most extraordinary virtues, and great beneficial properties, have been attributed to the same substance. In 1566 its use was prohibited in France by an edict of the Parliament, which was repealed in 1650, antimony having a few years before, been received into the number of *purgatives*. In 1668 a new edict came forth, prohibiting its being used by any one but by the Doctors of medicine. Thus much is certain, 1st, that Antimony in its crude state is not a poison, but a medicine of great efficacy; an excellent resolvent and purifier of the animal juices, if given from 4 *grains* to half a drachm (or 30 *gr.*) together with absorbents; 2dly, that it is capable of being rendered, by various operations and additions, either truly poisonous, or more medicinal than in its crude state: and, 3dly, that its most virulent preparations may, by slight management, be made salutary; and its most salutary ones virulent and deadly poisonous, as Newmann observes. *The Editor.*

a. Is nearly of the same colour as lead, but brittle; and changes sooner its shining colour in the air, first to yellow, and afterwards to black.

b. It appears laminated in its fracture, or where broken.

c. Is very volatile in the fire, burns with a small flame, and emits very disagreeable smell, like garlick [*a*].

It

[*a*] 1. If arsenic be laid on a red-hot iron, it burns with a slight flame, white smoke, and garlick smell: is wholly volatilized, and tinges a plate of copper, held over it, white.

2. The specific gravity of the radical acid of arsenic, is = 3391; of white arsenic = 3,706; of its glassy state = 500; and of its regulus = 8,301, or even 8,310.

3. *Aqua Regia* and muriatic acid perfectly dissolve arsenic; the *vitriolic*, however, requires to be boiling-hot. The *acetic* acid only acts upon its calx. The *nitrous* acid not only takes away as much phlogiston as may be expressed by 100; by the loss of which, the regulus is reduced to the state of a calx; but, in a large quantity, assisted by a proper degree of heat, it at length so far dephlogisticates this calx, as to leave the acid of arsenic alone.

4. From analogy it is probable, that every metal contains a *radical acid* of a peculiar nature, which, with a certain quantity of phlogiston, is coagulated into a metallic calx; but with a larger quantity, sufficient to saturate it, forms a compleat metal. *Bergman's Sciagr.* See what has been said on this subject, in the *Notes* to p. 307, 504, &c.

5. Gold, fused with arsenic in a close vessel, takes up scarcely $\frac{1}{10}$ of it; silver $\frac{1}{4}$; lead $\frac{1}{2}$; copper $\frac{2}{3}$; iron more than its own weight; bismuth about $\frac{1}{15}$; zinc $\frac{1}{2}$; regulus of antimony $\frac{1}{2}$; and manganese an equal quantity.

6. Iron, by means of less than an equal quantity of *arsenic*, loses its magnetic power. *Bergman's Sciagr.* and the second vol. of his essays, p. 283.

7. The arsenic, met with in commerce, is brought chiefly from the cobalt-works in Saxony, where zaffre is made.

Arsenic

- d. It is, by reason of its volatility, very difficult to be reduced, unless it be mixed with other metals. However, a regulus may be obtained from the white arsenic, if it be quickly melted with equal parts of pot-ashes and soap; but this regulus contains generally some cobalt, most of the white arsenic being produced from the cobalt ores during their calcination. The white arsenic, mixed with a phlogiston, sublimes likewise

Arsenic is contained in great quantities in the cobalt-ores, from which it is driven off by long torrefaction: these fumes pass into, and adhere to the sides of, a very long chimney constructed for that purpose.

8. But the greatest quantities are prepared at *Geyerberg*, near the village *Ehrenfriedersberg* in Misnia, from ores brought thither from *Schneeberg*, and other Saxon mines. The ore is thrown into a furnace resembling a baking-oven, whose flew is an horizontal pipe, near an hundred fathoms in length, of a considerable width at the beginning, but growing narrower to the further end. The ore is every now and then stirred and turned over to promote the extrication of the arsenic, which arises in fumes into the pipe, and there condenses into a greyish or blackish powder, called *Meal Arsenic*. This is refined by a second sublimation in close vessels, with a little pot-ash, which detains the impurities: the force of the heat melts the sublimed flowers into the crystalline masses, which are sold all over Europe.

9. What is called arsenic is the calx of its regulus; and contains no *fixed air*. It is so far in the saline state, as to be soluble in 80 parts of distilled water in the temperature of 59 degr. of Fahrenheit; but if the water be boiling, 15 parts will dissolve one of the arsenical calx.

10. The regulus of arsenic is obtained from its calx, either by quickly fusing it after it is made into a paste, together with twice its weight of *soft soap*, and an equal quantity of mineral alkali, and pouring it out, when fused, into an hot iron cone; or by mixing it, in powder, with oil, to the consistency

- likewise into octohedral crystals of a metallic appearance, whose specific gravity is 8,308.
- e. The calx of arsenic, which always, on account of its volatility, must be got as a sublimation, is white, and easily melts to a glass, whose specific gravity is 5,000. When sulphur is blended in this calx, it becomes of a yellow, orange, or red colour; and according to the degrees of colour is called *Orpiment* or *yellow arsenic*, *Sāndarach*, *Realgar* or *red arsenic*, and also *Rubinus Arsenici*,

This

consistency of a syrup, and distilling the whole gradually to dryness. Towards the end, the regulus sublimes, and may be made more perfect by a second distillation in a matrass, with its own weight of oil. This operation is too offensive to be made but in the open air. After this sublimation, the matrass is broken, and a crust is found in the neck, having a glassy appearance, and a metallic lustre. This glass, exposed to the air, loses its transparency, becomes milky, and blackens sensibly.

11. The calx of arsenic is the only metallic calx that dissolves in water, and affords pyramidal crystals by slow evaporation. It unites with earths, by means of fusion, and accelerates their vitrification; but all these glasses tarnish soon by exposure to air.

Bolling oils dissolve this semi metal, as Kirwan asserts.

12. Arsenic is not attacked by *vitriolic acid* when cold; but when they are boiled together in a retort, some sulphureous acid is produced, a little sulphur sublimes, and the arsenic is found in the form of a calx, but not at all dissolved.

13. The *nitrous acid* attacks it violently, calcines it; and, by a gentle heat, a considerable part of this calx is dissolved.

According to Bucquet, the *marine acid*, assisted by heat, dissolves arsenic, and its calx.

Both fixed and volatile alkalis precipitate the arsenic from this combination.

f. This calx and glass are dissoluble in water, and in all liquids; though not in all with the same facility. In this circumstance arsenic resembles the salts, for which reason it also might be ranked in that Class, at Sect. 155.

g. The regulus of arsenic dissolves in spirit of nitre; but as it is very difficult to have it perfectly free from other metals, it has hitherto been very little examined in various menstrua.

It

14. The regulus of this semi-metal, mixed with nitre, and thrown into a red-hot crucible, occasions a brisk detonation: but its calx, viz. *white arsenic*, does not sensibly deflagrate with nitre; and if the operation is made in an open vessel, it alkalizes the salt.

15. A mixture of arsenic and sulphur, being fused, produces either a *volatile yellow* compound, called *falsitious orpin*, or *orpiment*; or a red one if the heat is brisk, called *Falsitious Realgar*, *Rizagal*, or *Red Arsenic*. They are both volatile by fire, and may be decomposed by *lime*, and by *alkalis*, which have more affinity to the sulphur, than the arsenical calx. However, this calx, like the *acids*, may decompose the *livers of sulphur*.

16. All the properties of this calx of arsenic, prove it to be a combustible body, which, on being united to *vital air*, assumes the character of a saline substance. By distilling a mixture of *dephlogisticated marine acid* and of *calx of arsenic*, the *marine acid* attracts the phlogiston from the calx; and this last passes into the state of a true acid, as Scheele observed. He succeeded also in preparing *arsenical acid*, by distilling the calx of this semi-metal with four parts of nitrous acid. This last gives out much nitrous gas; and the calx assumes the character of an acid in a solid form, which must be very strongly, and very long heated to disengage the superabundance of the nitrous acid. The process for disengaging this acid, which has been formerly described at p. 298, is nearly the same; and as to its properties, they have been exposed already in Sect. 161.

What

b. It is poisonous, especially in form of a pure calx, or glass. But probably it is less dangerous when mixed with sulphur, since it is proved by experience, that the men at mineral works are not so much affected by the smoke of this mixture, as by the smoke of lead; and that some certain nations make use of the red arsenic, in small doses, as a medicine.

i. It unites with all metals, and is likewise much used by nature itself to dissolve, or,
as

17. What passes in these operations seems to countenance very well the new doctrine of the *Aerial Theory*. For the calx of arsenic, by its great affinity to *pure air* (which is the radical acidifying principle of those acids), combines with it, and becomes an acid itself, in the same manner as they had been formed.

18. It was with great hesitation, that I have hitherto resolved the principles of the new theory in my mind, on account of my being deprived of the true key for unfolding the whole. But having been favoured within these few days, with the system of the *New Nomenclature*, by the generous friendship of the Authors, I can but acknowledge its great superiority (if well supported by *real facts*): and I rejoice on this valuable acquisition to the philosophical world, for explaining the operations of Nature in the most simple and intelligible way. I must keep, however, to the former language in the remainder of these notes, *ut pes et caput uni reddantur formæ*, according to the old adage of Horace.

19. The arsenical acid has a strong taste. It may be fused in the fire, and thus may be freed from the portion of the arsenical calx it happens to contain still. It weakly reddens vegetable blue colours: exposed to the air, it loses its transparency, and gradually deliquesces. This salt is soluble in two parts of water, combines easily with *lime*, but more difficultly with *ponderous* and *magnesian* earths. It forms neutral salts, when united to alkalis, which, however, may be decomposed by *lime*, as Bergman asserts.

The

as we term it, to *mineralise* the metals, to which its volatility, and solubility in water, must greatly contribute. It is likewise most generally mixed with sulphur.

2. It absorbs, or expels, the phlogiston, which has coloured glasses; if mixed with them in the fire.

S E C T. 374. (239.)

Native Arsenic.

Arsenic is found,

1. Native, *Arsenicum nativum*; called *Scherbencobolt* and *Fliegenstein* by the Germans.

It is of a lead colour when fresh broken, and may be cut with a knife, like compact black lead, but soon blackens in the air. It burns with a small flame, and goes off in smoke.

- A. Solid and testaceous, *Arsenicum nativum particulis impalpabilibus testaceum*. *Scherbencobolt* [a].

20. The acid of arsenic, by the addition of any phlogistic substance, becomes white arsenic; and, by the addition of still more, assumes the appearance of a perfect semi-metal, though apparently no states are more opposite than those of a liquid acid, and of a solid metallic substance. *The Editor from Kirwan, Bergman, Fourcroy, &c.*

[a]. The *regulus of arsenic* is found with a metallic form, in Bohemia, Hungary, Saxony, Hercynia, and else where, but particularly at *St. Marie aux mines*, in Alsatia, where not long since many hundred weight of it were extracted. In
Germany

This is found in the mines of Saxony, the Hartz, and Hungary.

B. Scaly, *Particulis micaceis*, from Winhorn at Kongsberg in Norway.

C. Friable and porous; *Friabile et porosum*. *Fliegenstein*, in German [*b*].

With

Germany it is called not only *Fliegstein*, but also *Muckenpulver*, viz. *flie.-powder*; although it is difficult to guess for what reason this last name has been given to it, as this regulus is not soluble in water: and therefore, unless dephlogisticated, it is not at all proper for the purpose alluded to by such a name. Perhaps by some spontaneous calcination it became, one time or another, so much dephlogisticated as to acquire a degree of solubility, which answered to that purpose.

As to its form, it is often found shapeless, friable, and pulverulent; but sometimes compact, divided into thick convex lamellæ, with a needle-formed or micaceous surface. It admits of a polish, which, however, is soon lost by it's being exposed to the action of the air.

When fresh broken, it appears as if composed of small needle-like fibres, of a leaden colour; which soon grows yellow, and by degrees blackish. In hardness it seems to exceed copper, and in brittleness it resembles antimony. *Bergman, Dissert. 21. § 11.*

The native regulus of arsenic is seldom, if ever, found in a crystalline form, and possessing all the properties of the arsenical regulus. It is sometimes found mixed with various metals; and, it may be analysed by solution in *aqua regia*. The silver, if any, will remain precipitated: the iron, of which it commonly contains a small portion, will remain in the solution; and if a small quantity of water be added after decantation, the calx of arsenic will be precipitated, and the iron will remain. The Editor from Kirwan.

[*b*]. Some of the proper ores of arsenic are of a whitish; and others of a blackish colour; and both sorts have more or less of a sparkling aspect; the first are called *White Pyrites*, or *Alspieckel*, the latter *Fliegensteinertz*. They consist mostly of

1. With shining fissures, *Fissuris nitentibus*.
from Annaberg in Saxony.

This is by some called *Spigel Cobalt* (*Minera cobalti specularis*) according to their notions of the affinity of these metals to one another. However, there always remains after the volatilisation of the Scherbencobolt, some calx, either of cobalt or bismuth, and some silver, though in too small a quantity to deserve any notice.

S E C T. 375. (240.)

Calciform Arsenical ore.

2. In form of a calx, *Arsenicum calciforme*.

A. Pure, or free from heterogeneous substances, *Calx arsenici nativa pura* [*a*]:

of arsenic, blended with a considerable proportion of earthy or stony matter, but with little, if any, mixture of any other metallic body, *Newmann*, p. 226.

[*a*] This calciform ore is a true mineralisation of this semi-metal by the aerial acid.

It is called also Native *Calx of Arsenic*, and *Flos Arsenici*. by some mineralogists.

It does not detonate with nitre, though an effervescence arises.

Its specific gravity is from 3,706 to 5000.

Is soluble in about 70 or 80 times its weight of water in the temperature of 60 *degr.* of Fahrenheit's thermometer.

But in boiling water, 15 or 20 times its weight are sufficient to dissolve it.

The solution turns tincture of turnsole red: and syrup of violets green.

It is scarcely soluble in the *vitriolic* acid; something more in the *marine*, and most perfectly in the diluted *nitrous* acid.

The Editor from Kirwan.

Loose

1. Loose or powdery. This sort is found at Giesshubel in Saxony, but it is collected in a much purer state on the sides of the rock in some mines.
2. Indurated or hardened. This is found in form of white semi-transparent crystals, in small cavities within the Scherbencobolt, at Andreasberg in the Hartz, and in Saxony, but it is very scarce.

S E C T. 376. (241.)

Sulphurated Arsenic. Orpiment. [a].

A. Mixed with sulphur, *Calx arsenici sulphure mixta.*

1. Hardened.

a. Yellow. Orpiment, *Auripigmentum*, from Hungary [*b*].

Red,

[*a*] The orpiment may perhaps be found naturally in loose scaly powder, as it is sometimes met with in the shops. However, I have only seen the hardened sort in collections. *The Author.*

[*b*] Orpiment is naturally found in the earth; in general it is amorphous, and very seldom crystallized. Baron Borne once found it in a polyhedral form on a blue clay in Hungary.

It is generally composed of shining, flexible laminæ like mica, more or less solid.

Its specific gravity is about 5,315. It burns with a blue flame, and contains only about *one tenth* of its weight of sulphur.

Some pretend that orpiment, on account of the sulphur it contains, has no poisonous qualities, and may safely be

- b. Red, Native Realgar or Sandarach, from Hungary, Andreasberg in the Hartz, Saxony, and Rotendal in Elfdalen in Sweden [c].

S E C T. 377. (242.)

Arsenic mixed with metallic calces.

- C. Mixed with the calx of tin, in the tin-grains. Sect. 299, (181) and 301.
 D. With sulphur and silver, in the Rothguldén, or red silver ore, Sect. 270 and the 5 following.
 E. With calx of lead, in the lead-spar. Sect. 308.

be used internally; but Maquer very positively asserts the contrary, and gives a very serious warning against its use, even if the orpiment be truly native. *The Editor from Fourcroy and Kirwan.*

[c] The red-arsenic, or realgar, called otherwise *Rawschgelbe* by the Germans, is found in irregular, or stalactitical masses.

It is either opaque, or semi-transparent; sometimes it is found transparent, and regularly crystallized in octohedral pyramids, or prisms; in this last form it is called *Ruby of Arsenic*.

Its specific gravity is $\approx 3,225$.

It contains 16 parts of sulphur *per* hundred weight.

Nitrous acid soon destroys its redness.

To analyse these ores, they should be digested in *marine acid*, adding the *nitrous* by degrees to help the solution. The sulphur will be found on the filter; and the arsenic will remain in the solution, from which it may be precipitated in its metallic form by zinc, adding spirit of wine to the solution. *The Editor from Kirwan.*

G g g

With

F. With calx of cobalt, in the efflorescence of cobalt. Sect. 384.

S E C T. 378. (243.)

Mineralised Arsenic.

3. Mineralised arsenic, *Arsenicum mineralisatum*.

A. With sulphur and iron, *Arsenicum ferro sulphurato mineralisatum*. Arsenical pyrites or marcasite [d].

This alone produces red arsenic, in roasting: and is found in great quantities in the mines of Lofas in the province of Dalarna. It is of a deeper colour than the following.

B. With iron only, *Arsenicum metalliforme ferro mixtum*. *Mispickel* [e]. This differs with regard to its particles, being

1. Steel-grained;
2. Coarse-grained, from Westersilverberget;

[d] These kinds in Cornwall are called Silvery or White Mundics, and Plate Mundics. D. C.

[e] The mineral, commonly called *Mispickel*, is justly reckoned a regulus of arsenic, as, when totally deprived of sulphur, it consists of iron and arsenic united in a metallic form: and although the iron amounts to $\frac{1}{3}$, or sometimes even to $\frac{2}{3}$, yet the compound is not *magnetic*, but if ignited, sends forth an arsenical smell, and is soon rendered magnetic, though the operation be performed on a tile, without any phlogiston. See note d to p. 741. It easily flows in the fire; and, in close vessels, the greater part of the regulus rises, leaving the iron to the bottom. A compound of this kind may also be artificially made. *Bergman*, De Arsenico,

§ 2.

Crystallized

3. Crystallised.

2. In an octohedral figure. This is the most common kind.

5. Prismatical, from the mines of Salberg, Westerfilsverberget, and Hellefors in Westmanland, and in many places of foreign countries [f].

S E C T. 379. (244.)

Arsenic Mixed with metals.

C. With cobalt, in almost all cobalt ores.
Sect. 382. 384. and 386.

D. With silver. Sect. 271 and following.

E. With copper. Sect. 327.

F. With antimony. Sect. 370.

S E C T. 380. (245.)

OBSERVATIONS ON ARSENIC [g].

Such ores as consist of arsenic united solely with iron, or with iron and sulphur, cannot be

[f] The sulphureous marcasite is added to this kind, when *red arsenic* is to be made; but in Sweden it is scarcer than the sulphureous arsenical pyrites *The Author.*

[g] 1. It can hardly be doubted, that arsenic may be applied to valuable purposes in medicine; as various experiments have proved in different applications. But, in respect

G g g 2

both

be employed to any other use than to the preparation of arsenical products; for which reason they ought to be ranged among the arsenic ores. Some have indeed denied this difference between the arsenical pyritæ; but it is however necessary to make some difference, with respect to the presence or absence of sulphur, although the greatest quantity of arsenic is got from the calcination of the cobalt ores, and that the true arsenical pyritæ do not deserve to be separately employed.

Although

both to its dose and preparation, the utmost caution must be used, for it is beyond any dispute that arsenic is the most virulent of all poisons, and that, even when externally applied, it often produces very pernicious effects.

2. Phlogiston and alkalis seem to be the best correctors of the corrosive acrimony of arsenic; and may be applied to obviate its deleterious effects. It was thought of course, that the *neutral arsenicated salt* of Macquer, being saturated with the vegetable alkalis, would not produce those noxious effects; but Mr. de Morveau asserts, that upon trial this neutral salt is in fact a very stupifying poison.

3. Hence too it appears, says Bergman, why *realgar* is less noxious, why the regulus is milder than white arsenic, and this again milder than the *dry acid*: why the baths of *Carlsbad*, which contain a *mineral alkali* only, united with aerial acid, are extremely useful in diseases occasioned by arsenic: why *arsenic*, taken internally without the necessary correction, occasions, by its irritating quality, convulsive motions, among other symptoms, both in the stomach and other parts of the body.

4. Of all metals arsenic most easily loses its phlogiston; we therefore should be cautious in confiding to phlogistic correctors, as the phlogiston may be separated in the viscera by many different ways.

5. The symptoms of such as in a fit of despair, have taken a dose of arsenic, begin to appear in about half an hour

Although it is difficult to reduce the arsenic by way of precipitation, one cannot for that reason deny it to be of a metallic nature; for the same reasoning might have been used against the existence of zinc in the calamine, before the method to extract that semi-metal in its metallic state, now known, was discovered. But those who know that metals only can be mixed with metals, so as to preserve the solidity and some ductility in the compound, and who at the same time are ignorant of any metallic earth which cannot be reduced to its metallic state again, could never entertain such notions.

It is indeed true, that sulphur, in regard to the brittleness which it produces in metals, is
of

hour after, by a nausea, sickness, and reaching; these are followed by violent vomitings, hiccups, and pains in the stomach and bowels: convulsions and palsies in the limbs, intense heats, cold sweats, and palpitations of the heart, extreme anxieties, restlessness, prostration of strength, thirst and dryness of the mouth and throat, loss of reason, and at last death. If the quantity taken has been considerable, the stomach and intestines are found, upon dissection, corroded and perforated; though in general the patient expires before the further action of the poison can take place: and the most experienced physicians acknowledge, that no antidote can overcome the destructive efficacy of this poison.

6. A preparation of arsenic with nitre has been once highly extolled, as a febrifuge, at Berlin; but arsenic, however prepared, continues to retain its poisonous quality. Even the external application of this substance has produced many times the most dangerous consequences: and Doctor Mead has shewn that the use of arsenic, as an antipestilential pre-

of no worse effect than arsenic ; but this last may by itself, and mixed only with a pure phlogiston, be sublimed into a metallic form, which is more plainly seen in the Scherbenecobolt (Sect. 374.). I easily perceive that it may be objected by those who deny arsenic to be a semi-metal, that it may as well be a salt of a peculiar nature ; as, for instance, the vitriolic acid is ; and that it may, like sulphur, dissolve the metals in form of a kind of regulus ; and farther, that its assuming a metallic appearance, when it is united with an inflammable substance, is of no consequence ; since there are fish and insects who have a shining metallic colour : to this little can be answered, since it has been already agreed, that systems must not be too severely criticised.

S E C T.

servative among the Arabians, is grounded on a mistake of the word *darfini*, which is nothing else but a preparation of cinnamon with other aromatics, &c.

7. The *philothrum Turcicum*, or pomatum of Turkey, contains orpiment, among others substances ; but its depilatory power is perhaps more properly ascribed to the caustic alkali.

8. Philosophers evince the extraordinary porosity of bodies, and the wonderful subtilty of vapours, by the sympathetic ink. This is composed of *caustic fixed alkali*, boiled in water with orpiment, which yields a fœtid hepatic solution, in which state it is used as such. Orpiment, also, boiled in water, with double the weight of quicklime, affords a *probatory liquor*, which may be employed for proving wines ; for when they are naturally acid, or grown so by age, the owners still dare to continue to edulcorate them, with sugar of lead ; notwithstanding the punishment of the law, if detected : but some drops of this probatory liquor being thrown into a
glass

S E C T. 381. (246.)

6. Cobalt. *Cobaltum*.*Its general properties [a].*

6. This semi-metal is,

- a. Of a whitish grey colour, nearly resembling fine hardened steel.

Is

glass of suspected wine, if it is adulterated, a *brown* or *black sediment* will be precipitated: otherwise, if the wine is pure, it will occasion nothing but a *yellow precipitate*.

N. B. A large proportion of tartar in the wine, will render the probatory liquor ineffectual; as the tartarous acid will form with the lime a *white salt*, very difficult of solution.

Mountain-crystals placed over *orpiment*, *white arsenic*, *crude antimony*, and *sal ammoniac*, mixed in a crucible, are tinged by means of heat, with a beautiful red, yellow, and *opal colours*, as Neri has described; but they very often crack in the operation.

In painting likewise the artists employ arsenic. Painters in oil, frequently use *orpiment* and *realgar*, and a beautiful *green pigment* may be precipitated from blue vitriol, by means of white arsenic dissolved in water, together with vegetable alkali. This, prepared with water or oil, affords a colour which suffers no change in many years; but must not be applied to any kind of sweetmeats, or food, as it is really very poisonous. *The Editor from Bergman, Kirwan, &c.*

N. B. Arsenic whitens fused copper. See note [1], p. 711.

[a] The colour of regulus of cobalt is rather of a bluish grey; and its specific gravity is about = 7,700.

Its fusibility is like that of copper, or even gold; and, when well purified, it is hardly easier to melt than iron.

If melted cobalt is slowly cooled, it crystallises, forming in its surface small bundles of needles, or needle-form prisms,

G g g 4

laid

- b.* Is hard and brittle, and of a fine grained texture; hence it is of a dusky, or not shining appearance.
- c.* Its specific gravity to water is 6000 :: 1000.
- d.* It is fixed in the fire, and becomes black by calcination; it then gives to glasses a blue colour, inclining a little to violet, which colour, of all others, is the most fixed in fire.
- e.* The concentrated oil of vitriol, aqua fortis, and *aqua regia*, dissolve it; and the solutions become red. The cobalt calx is likewise dissolved by the same menstrua, and also by the volatile alkali, and the spirit of sea-salt.

When

laid on one another, and united into bundles. Mongez observed, that they greatly resemble a mass of shaken basalt.

In order to succeed in this crystallization, it is sufficient to fuse cobalt in a crucible, till it suffers a kind of ebullition; and, after having taken it from the fire, to incline the vessel, while the surface of the semi-metal is congealing. By this inclination the portion still fused is poured out, and that which adheres to the sides of this kind of geode, formed by the cooling the surfaces of the cobalt, is found covered with the crystals sought for.

Melted with borax it affords a *blue* glass, which is the most obvious property for distinguishing its ores amongst all others.

It is difficultly calcined; and

Its calx, although it appears black, is in fact of a very deep blue.

This calx is not volatil; and being melted with borax, or potash, and siliceous sand, it produces a blue glass, called *smalt*.

The regulus of cobalt is easily soluble in *spirit of nitre*, and *aqua regia*.

- f.* When united with the calx of arsenic in a slow (not a brisk) calcining heat, it assumes a red colour. The same colour is naturally produced by way of efflorescence, and is then called the *bloom* or *flowers of cobalt*. When cobalt and arsenic are melted together in an open fire, they produce a blue flame.
- g.* It does not amalgamate with quicksilver by any means hitherto known.
- b.* Nor does it mix with bismuth, when melted with it, without addition of some medium to promote their union.

The colour of this solution, as well as that made in any of the other acids, and in *volatil alkali*, is either *red* or of a *rose-colour*.

This solution, diluted with water, is a sympathetic ink, as the writing with it does not appear when dry; but, on being moderately warmed, it becomes of a fine green colour.

Its precipitate, by common or phlogisticated alkali, is of a reddish-ash colour.

It difficultly dissolves in *vitriolic acid*; and scarce at all in the *marine*, unless heat be employed. The *marine* solution is a sympathetic ink, and it is on account of the *marine* part in the *aqua regia*, that the above solution has the same property.

The calx, however, of this semi-metal is more easily dissolved by these acids, and yields even to the *acetous acid*.

It is worth notice that the red colour of the acid solutions of cobalt when diluted with water, instead of fading, seems to become more vivid.

Cobalt does not combine by fusion with silver, bismuth, or lead.

It is most strongly attracted by the acid of sugar, which precipitates it from the other acids, in the form of a pale rose coloured powder.

The acid of sorrel, also precipitates cobalt from the muriatic and other acids. *The Editor from Bergman, Kirwan, and Fabroni.*

S E C T.

S E C T. 382. (249.)

Native Cobalt [b].

B. 1. With arsenic and iron in a metallic form, *Cobaltum ferro & arsenico metalliformi mineralisatum*; vulgè *Cobaltum dictum*.

This

[b] Pure native cobalt has not yet been found: that which passes for such, according to Kirwan, is mineralized by arsenic. Bergman, however, in his *Sciagraphia*, has entered this present ore, under the denomination of *native cobalt*: and certain it is, that among all the cobaltic ores, this is the nearest to the *native* state of this semi-metal. It always contains a small quantity of iron, besides the arsenic, by which it is mineralized.

This is generally called the *Grey Cobalt Ore*, and Glantz-cobalt; or *Stahl Derben Cobalt*, by the Germans; and, besides the places mentioned by the author, it is also found in some parts of England, particularly at Mendip Hills in Somersetshire, and in Cornwall, in which last country Dr. Lewis asserts it to have of late been dug out in considerable quantities. Klaproth, in his account of the fossils of Cornwall, asserts, that at Dolcoth in this last country, the grey cobalt ore is found either without, or with bismuth; he adds, that it resembles very much in colour, fracture, and other external appearances, the cobalt-ores from Rappold at Schneeberg, in the district of Misnia in Saxony: and having made various and repeated trials of these English cobaltic ores, he found them to produce the finest blue colours, when properly vitrified.

An arsenicated grey cobalt ore, combined with galena, was found also in the year 1783, by Mr. Brolman, at Chateaudren; as it is asserted in *Journal, de Physique* for Sept. 1787, p. 177.

This

This is of a dim colour when broken, and not unlike steel. It is found

- a. Steel-grained, from Loos in the parish of Farila, in the province of Helsingeland, and at Schneeberg in Saxony.
- b. Fine grained, from Loos,
- c. Coarse-grained.
- d. Crystallised.
 1. In a dendritical or arboresecent form, from Schneeberg.
 2. Polyhedral, with shining surfaces; the *Glantz kobolt* of the Germans, from Schneeberg.
 3. In radiated nodules, from Kongsberg in Norway,

S E C T.

This ore is of a solid, heavy, and compact texture. Sometimes of a dull, and sometimes of a bright appearance; frequently crystallized in a tessellar, and sometimes in a dendritical form,

And in general is so hard as to give fire with steel; and an arsenical smell is then perceived.

It grows black in the fire; is soluble with effervescence in *nitrous acid*, from which it may be precipitated by the *marine*; and affords the sympathetic ink, mentioned already in the notes to Sect. 381.

In order to distinguish this from the arsenical ores of the same appearance, the two principal characters of cobalt, *viz.* the sympathetic ink, and the blue colour given to glass, are fully sufficient.

It is analysed by solution in *aqua regia*, or *nitrous acid*, and evaporation to dryness. The residuum treated with the acetous acid will yield to it the cobaltic part; but the arsenic should be first precipitated by the addition of water.

Or else this ore may be first roasted to expell the arsenic; and then if treated with *nitrous acid*, the cobalt will be dissolved with the small portion of iron; and, by boiling the solution,

S E C T. 383. (247.)

Calciform Cobalt [a].

The cobalt is most commonly found in the earth mixed with iron.

A. In form of a calx, *Cobaltum calciforme*.

1. With iron without arsenic, *Martiale absque arsenico*.

solution, most of the iron will be precipitated: by adding fixed alkali, the remainder of the iron will be first precipitated *yellowish*, and afterwards the cobalt will fall down of a reddish colour.

The Prussian alkali may also be employed, to precipitate first the *iron* of a blue colour, and afterwards the cobalt *reddish*, or rather *grey*. The Editor from *Bergman, Kirwan, Mongez, &c.*

[a] This ore seems to be the aerated cobalt of Kirwan, p. 336 of his *Elem. of Mineralogy*.

It is called the *Black Ore of Cobalt, Vitreous Ore, Kobalt Mulinum*, and *Schlaken-Kobalt*, by the Germans.

It is found in a loose, powdery form. Sometimes resembling *lamp-black*, either grey or blackish, and then called *Cobalt Ore*.

When in black indurated scoriform masses, it is called *Schlaken Kobalt*, or *Vitreous Cobalt*. They are free from sulphur and arsenic; and if these be present, they are only mechanically mixed.

A small portion of copper and iron is also sometimes found in it.

This ore is frequently imbedded in stones, or sands of a black colour. Talc, chalk, and gypsum, impregnated with it, are called by the same name; and by some *Spiegel Cobalt*. It is sometimes also contained in some green and blue earths of the argillaceous kind. *Kirwan*, p. 336.

Loofe

- a. Loose or friable, *Minera cobalti calciformis pulverulenta*. Cobalt ochre, *Ochra cobalti nigra*. It is black, and resembles the artificial zaffre.
- b. Indurated, *Minera cobalti calciformis indurata*. *Minera cobalti vitrea*, the *schlacken* or slag cobalt.

This is likewise of a black colour, but of a glassy texture, and seems to have lost that substance which mineralised it, by being decayed or withered. It is often confounded with the Scherbencobolt, for it is seldom quite free from arsenic; and there may perhaps exist a progressive series from the Schlacken kind to the Scherbencobolt kind (of Sect. 374.).

S E C T. 384. (248.)

2. Combined with Arsenical Acid[d].

This ore is the *Minera cobalti calciformis acido arsenici mixta*: or *Cobalt-blut*.

[d] This ore is found also either *loose* and *pure*; or mixed with *chalk* or *gypsum*; or indurated and crystallized in tetrahedral crystals; or in a stalactitical form.

It melts easily, and then becomes blue.

It frequently invests other cobaltic ores: and is found sometimes in stone and sand. Bergman has shewn that the arsenical *acid*, and not the *calx* of arsenic, as the text erroneously expressed, enters into this combination; for cobalt is never *red* but when united to an acid. Kirwan, p. 337.

Flowers of cobalt, mineralized by arsenic, without any silver, and intermixed with galena, were discovered, on the mountain near the village of Atène, by Mr. Schreiber. See *Journal de Physique* for September 1787, p. 177.

Ochra

Ochra cobalti rubra, Bloom, Flowers, or Efflorescence of cobalt.

a. Loose or friable, *Ochra cobalti pulverulenta*.

This is often found of a red colour like other earths, spread very thin on the cobalt ores: and is, when of a pale colour, erroneously called Flowers of Bismuth [*e*].

b. Indurated, *Ochra cobalti rubra indurata*.

Hardened Flowers of Cobalt.

This is commonly crystallised in form of deep red semi-transparent rays or radiations: It is found at Schneeberg in Saxony.

SECT. 385. (250.)

Cobalt with sulphurated iron, Cobaltum ferro sulphurato mineralisatum [*f*].

This ore is of a lighter colour than the preceding, nearly resembling tin or silver. It is found,

[*e*] A white cobalt-earth, or ochre, is said to have been found. It has been seen and examined by a celebrated mineralist, who found it in every respect, except the colour, to resemble the cobalt flowers; and it is very possible, that those cobalt flowers might in length of time have lost their red colour, and become white. *The Author*.

[*f*] This ore is sometimes found in large masses, and sometimes in grains crystallised, of a dull white colour, and frequently bears the appearance of *Mispickel*. It has no mixture of arsenic.

It becomes *black*, and not *red*, by calcination, which distinguishes it from pyrites. And it contains so little sulphur that none can be extracted from it.

When dissolved in *aqua regia* its solution is *yellow* while cold, but when boiling becomes *green*, which alternation of colour is peculiar to *marine cobalt*. The Editor from Kirwan, p. 349.

a. Crystallised

a. Crystallised.

1. In a polygonal form.

a. Of a flaggy texture.

b. Coarse-grained.

This kind is found in Bastnasgrufva at Raddarshyttan in Westmanland, and discovers not the least mark of arsenic. The coarse-grained becomes slimy in the fire, and sticks to the stirring hook during the calcination in the same manner as many regulæ do. It is a kind of regulæ prepared by nature.

That sort which is of a flaggy texture is very martial, and is described by the mine-master Mr. Brandt, in the Acts of the Swedish Academy of Sciences for the year 1746. Both these give a beautiful colour.

S E C T. 386. (251.)

Combined with sulphurated and arsenicated iron [g].

3. With sulphur, arsenic, and iron, *Cobaltum cum ferro sulphurato et arsenico mineralisatum.*

[g] This ore has a great resemblance to the *Stahl derben Kobalt*, mentioned in the note to Sect. 382: but it is softer, for it never strikes fire with steel, and may sometimes even be scraped with a knife.

It mostly appears under some polygonal form.

The most shining sorts of this ore, and of the former species, have been called *Cobalt Glantz*.

It is analysable like the other cobalt ores, and the sulphur may be caught in the filter. Kirwan, p. 339.

This

This resembles the arsenicated cobalt ore, being only rather of a whiter or lighter colour. It is found

a. Coarse-grained.

b. Crystallised.

1. Of a polygonal figure, with shining surfaces, as the *Glanzkobalt* pag. 827.

It occurs at Tunaberg in the province of Sodermanland, partly of a white or light colour, and partly of a somewhat reddish yellow.

S E C T. 387. (252.)

4. With sulphurated and arsenicated nickel and iron.

See *Kupfernickel* in Sect. 256 of the Author

S E C T. 388. (253.)

OBSERVATIONS ON COBALT [*b*].

Since the glass of cobalt, which has been entirely freed from all arsenic in the calcination,

[*b*] The great consumption to which cobalt is employed, consists only in the application of the permanent blue colour it affords to glasses and enamels, either upon metals, or on porcelains, and earthen wares of all kinds. It is also the same blue, prepared in a very cheap way by the Dutch, from the coarse zaffre, or blue glass of cobalt chiefly, and called *Azur de Hollande* by the French, which is employed by laundresses. But, although cobalt is applied to hardly any other purposes, these alone render very profitable this semi-metal to the happy possessors

tion, and from the iron and the other metals by scorification, as when it is prepared from cristallised cobalt flowers, may by addition of phlogiston be melted to a true cobalt regulus, which differs in its qualities from all other metals; there can be no reason for denying the cobalt a place among the semi-metals, as many authors even at this time do, notwithstanding the several reasons given, which might induce them to examine nearer into the subject.

It was the Mine-master Mr. Brandt who first discovered this semi-metal, and described it in the abovementioned History of Semi-metals, in the *Acta Upsaliensia* for the year 1735.

The

possessors of its mines, if they are productive enough of its ore, to be worked on a large scale.

Ores of cobalt are found in several parts of Europe; the most plentiful are worked near Schneeberg, in the district of Misnia in Saxony; also at St. Andreasberg in the upper Hartz, where large quantities have been met with for upwards of 30 years past. Some centuries ago there was but an iron ore in this last place; but, about the beginning of the fourteenth century, on sinking deeper, it was succeeded by a very rich ore of silver. This also being at length exhausted, gave place to cobalt-ores. Some pieces are sometimes found in these mines that contain silver and gold. These metals, however, are only accidental, and not essential, as some rashly suppose, to the existence of cobalt ores.

The general method of preparing cobalt ores in the large way seems confined to Saxony alone, from whence all other parts of the world, even the East-Indies, are constantly supplied. It is supposed that the Chinese and more particularly the Japanese, had formerly mines of excellent cobalt, with which

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the

The brittleness of the cobalt regulus is no proof against its being a semi-metal; that property being the basis on which the distinction between the semi-metals and metals is founded. The earth of cobalt is fixed and vitrifiable in the fire, as well as that of copper and iron; and the colour of its glass being so immutable in the fire, proves it to be a particular substance, distinct from other earths and metallic calces.

The experiment of making a cobalt glass from iron or steel and arsenic, will certainly never succeed, unless the arsenic, employed for that purpose, has been made from a cobalt ore; but if the origin of the colour should be ascribed

the fine blues of their ancient porcelanes were painted; but it appears that these mines are now exhausted; and that the inferior blues of their present wares are painted with the Saxon zaffre, imported to them by the Dutch.

In regard to the management of this article at large, as employed in Saxony, the following is the abstract. The cobalt taken out of the mine, is broken with hammers into pieces, about the size of an hen's egg; and the stony involucre, with such other heterogeneous matters as are distinguishable by the eye, are separated as much as possible. The chosen mineral is then pounded in stamping mills, and sifted through brass wire sieves. The lighter parts are washed off by water, and it is afterwards calcined in a large flat-bottomed arched furnace, resembling a baking oven, where the flame of the wood reverberates upon the ore: this is occasionally stirred and turned during the calcination, with long handled iron hooks or rakes; and the process is continued till it ceases to emit any fumes. The oven or furnace is terminated by a long horizontal gallery, which serves for a chimney; in which the calx of arsenic, naturally mixed with the ore, sublimes, condenses, and is fused into a glass, which is sold,

in

ascribed to an irreducible metallic earth, there is no occasion for this experiment; because a cobalt regulus may be prepared so as to be free both from arsenic and iron, the presence of this last metal being easily discovered by the loadstone.

It is therefore now unnecessary and ridiculous to continue the old definitions of the cobalt, in which the Speise, which partly is a cobalt regulus, and partly a compound, consisting of nickel, cobalt and bismuth, united with sulphur and arsenic, is either confounded with the semi-metal itself, or quoted as a proof, that cobalt regulus cannot exist in any other manner than as a dead earth involved in heterogeneous

in commerce, by the improper name of *White Arsenic*. If the ore contains a little *bismuth*, as this semi-metal is very fusible, it is collected at the bottom of the furnace. The cobalt remains in the state of a dark grey calx called *zaffre*. One hundred pounds of the cobalt ore lose 20 and even 30 *per cent.* during this operation, which is continued 4 or even 9 hours, according to the quality of the ore. The roasted ore being taken out from the furnace, such parts as are concretioned into lumps, are pounded and sifted afresh. This roasted powder of cobalt is the true *zaffre*. But the *zaffre* in the commerce is never pure, being mixed with two, or rather three parts of powdered flints. A proper quantity of the best sort of these, after being ignited in a furnace, are thrown into water, to render them friable, and more easily reduced to powder, which, being sifted is mixed with the *zaffre*, according to the before-mentioned dose: and the mixture, is put into casks, after being moistened with water. This is the substance commonly sold under the name of *zaffre*.

As to *smalt* it is no more than a vitrification of one part of the *calcined cobalt*, fused in a large crucible with two of *flint-powder*, and one of *pot-ash*.

heterogeneous substances; which is the same as to conclude, that no pure copper can be produced from the copper regulus or fusions, called *Trottsfen* or *Spursten*.

These false notions have, however, induced a late author to describe the cobalt as a mixture of iron, copper, lead, bismuth, and arsenic; but he has not at the same time published any experiments which might serve to confirm his opinion; amongst which, with great reason, such experiments are expected as imitate nature in this composition, which is pretended to consist of so many different things. It might then have been calculated, whether it would be profitable to establish manufactures for making

At the bottoms of the crucibles in which the *smalt* is manufactured, is generally found a regulus of a whitish colour, inclining to red, which is extremely brittle. It is melted afresh, and when cold it separates into two parts; that at the bottom is the cobaltic regulus, which is employed to make more of the *smalt* by the process already described: and the other at the top is bismuth: for those two semi-metals are found very often mixed in the natural ores.

But to assay ores of cobalt in small quantities, by the dry way, it is enough to free them carefully from their matrix, and from all other heterogeneous matters: after which they are pounded, sifted, and washed: their sulphur is separated by roasting: and lastly they are to be melted with three parts of *black flux*, in a lined and covered crucible, on a smith's forge. The best of these ores afford from 60 to 80 *per cent* of *regulus*; and the worst under 25 *per cent*.

To assay the tinging power of cobaltic ores, the roasted ore is to be melted in a crucible with 3 times its weight of *pot-ash*, and 5 times of pounded glass, or prepared *flint*.

The

ing cobalt-glass, or zaffre, in any part of the world, where the abovementioned ingredients can be had.

The word Cobalt in Germany, and especially at the mineral works in Saxony, is applied to the damps, the arsenic, its vapours, and their effects on man; which has induced the vulgar also to apply it to some pretended evil spirit, which is said to dwell in the mines. But time will abolish these superstitions, which have their origin in ignorance.

S E C T. 389. (254.)

1. Nickel. *Niccolum*.

Its general properties [a].

This semi-metal was first described by its discoverer Mr. Cronstedt in the Acts of the

The *pot-ash* is to be put in first, then the *glass* or *flint*, and over all the *ore*.

If any bismuth be contained in the cobalt ore, it will not mix with the regulus of cobalt, unless nickel be also contained in it, but will simply adhere to it; and may be separated by the hammer, or by fusion; for the bismuth melts much more easily than cobalt.

When cobalt is united by means of nickel to bismuth, the compound is called *speiss*. This is the name given also to a compound of *cobalt*, *nickel*, *bismuth*, *sulphur*, and *arsenic*. The Editor from *Kirwan*, p. 340 and *Lewis*, &c.

[a] 1. Nickel is a reddish-white semi-metal of great hardness, so that it can scarce be filed.

2. Its texture is equable, or uniform; and

3. It varies in its specific gravities, according to its purity; from 7421 to 9000; the purest being the heaviest.

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4. When

Royal Academy of Sciences at Stockholm, for the years 1751 and 1754, where it is said to have the following qualities: That

1. It is of a white colour, which however inclines somewhat to red.
2. Of a solid texture, and shining in its fracture.
3. Its specific gravity to water is as 8,500 :: 1,000.
4. It is pretty fixt in the fire; but together with the sulphur and arsenic, with which its ore abounds, it is so volatile, as to rise in form of hairs and branches, if in the calcination it is left without being stirred.
5. It calcines to a green calx.
6. This calx is not very fusible, but it however tinges glass of a transparent reddish brown, or hyacinth colour.
7. It dissolves in aqua fortis, aqua regia, and the spirit of sea-salt, but more difficultly in the vitriolic acid, tinging all these solutions

4. When very pure, it is in some degree malleable; and

5. Is always magnetic; from whence it is deemed to retain iron, though this seems to be rather a property belonging as well to itself, because it appears to increase with its depuration.

6. It gives a hyacinthine colour to glass, which should be blue whilst it contained some mixture of cobalt.

7. The fusibility of the common regulus is nearly the same as that of copper.

8. But the purest regulus is much more difficultly melted, or calcined.

9. It calcines more difficultly than cobalt; and,

10. Its

lutions of a deep green colour. Its vitriol is of the same colour; but the colcothar of this vitriol, as well as the precipitates from the solutions, become by calcination of a light green colour.

8. These precipitates are dissolved by the spirit of sal ammoniac, and the solution has a blue colour; but being evaporated, and the sediment reduced, there is no copper, but a nickel regulus is produced.

9. It has a strong attraction to sulphur; so that when its calx is mixed with it, and put on a scorifying test under the muffle, it forms a compound with the sulphur which resembles the yellow steel-grained copper-ores, and is hard and shining on its convex surface.

10. It unites with all the metals, except quicksilver and silver. When the nickel regulus is melted with the latter, it only adheres to it, both the metals lying near one another on the same plane; but they

10. Its calx, which is *green*, rises in a tuberoso fungous form; but if nickel is thoroughly purified from arsenic, its calces are of a brown colour.

11. It is difficultly soluble in the *vitriolic* or *marine* acid, but easily in the *nitrous*.

12. All these solutions, which are *green*, turn to blue by the addition of volatil alkali; but iron discovers no copper in them, as it does in every combination of *copper*, *sulphur*, *iron*, *arsenic* and *cobalt*.

13. Hence nickel must be deemed a distinct semi-metal. Besides, Bergman has shewn that *sulphur*, *arsenic*, and *cobalt*, may be perfectly separated from nickel, though perhaps *iron* cannot without the utmost difficulty.

they are easily separated with a hammer.

11. Cobalt has the strongest attraction to nickel, after that to iron, and then to arsenic. The two former cannot be separated from one another but by their scorification, which is easily done, since

12. This semi-metal retains its phlogiston a long time in the fire, and its calx is reduced by the help of a very small portion of inflammable matter: it requires, however, a red heat before it can be brought into fusion, and melts a little sooner, or almost as soon as copper or gold, consequently sooner than iron.

S E C T. 390. (Additional.)

Native Nickel.

This is mentioned by Mr. *Rinman* to have been lately found in a mine of cobalt in *Hesse*;

It is very heavy, and of a liver colour, that is, dark red;

When pulverized and roasted under a muffle, it forms green excrescences; and smokes, but

14. It is, however, very evident, that if nickel has itself the property of being *magnetic*, as it was asserted N^o 5, the test of the load-stone will always indicate, as if it contained a mixture of iron.

It is very probable, therefore, that nickel itself may be *magnetic*; and this seems to be the real case, as the more it is purified from iron, it becomes *more*, instead of *less* magnetic; and even acquires, what iron does not, the properties of a true magnet. *The Editor from Bergman and Kirwan,*

its smoke has no particular smell: and no sublimate, whether sulphureous or arsenical, can be caught;

It is soluble in acids,

And the solution is green;

But a polished iron plate discovers no copper.

S E C T. 391. (255.)

Aerated Nickel.

The nickel is found.

A. In form of a calx, *Niccolum calciforme*.

Nickel ochre, *Ochra niccoli*.

1. Mixed with the calx of iron, *Ochra niccoli martialis*.

This is green, and is found in form of flowers on Kupfernickel. In Normarken in the province of Wermeland, this ochre was found without any visible nickel mixed in the clay, which contained a great quantity of native silver. *Sect.* 266, p. 542.

S E C T. 392. (256.)

Kupfer nickel [b].

B. Mineralised nickel. *Niccolum mineralisatum*.

1. With

[*b*] This ore is of a reddish-yellow, bright colour. Its texture is either uniform, granular, or scaly. It is bright in its fracture.

1. With sulphurated and arsenicated iron and cobalt, *Niccolum ferro & cobalto arsenicatis et sulphuratis mineralisatum*. *Cuprum niccolai seu niccoli*. *Kupfernickel* [c].

This is of a reddish yellow colour, and is found,

- a. Of a flaggy texture, in Saxony.
- b. Fine-grained, and
- c. Scaly, in Loos cobalt mines in the province of Helsingeland; at which place it is of a lighter colour than the foreign ones. These two are often, from their colour, confounded with the liver-coloured marcasite. Sect. 153.

S E C T. 393. (257.)

Vitriolated Nickel.

2. With the acid of vitriol, *Niccolum acido vitrioli mineralisatum*.

This is of a beautiful green colour, and may be extracted out of the nickel ochre, (Sect. 391.) or efflorescence of the Kupfer-nickel. See Sect. 211.

Is very heavy; and

Is generally covered with a greenish efflorescence.

By calcination it loses much of its sulphur, and becomes green, forming fungous ramifications. *The Editor from Kirw.*

[c] Mr. Raspe assured me, that to his certain knowledge, nickel was found mineralized with sulphurated iron and copper, in a mine near Nelson, in Cornwall. *The Editor.*

S E C T.

S E C T. 394. (258.)

OBSERVATIONS ON NICKEL [*d*].

The cobalt, bismuth, and nickel, are commonly found together in the same mines, from which circumstance it happens, that, when the first, as the most useful of them all, is to be made into glass, the adherent nickel, according to its nature, unites with the sulphur and arsenic, of which some portion remains after the calcination, and forms a compound with them. When these minerals (the sulphur and arsenic) are in greater quantity than is wanted for the nickel, they likewise reduce some part of the calces of the cobalt and bismuth; and in this case the nickel, as a medium, uniting the other two, otherwise not miscible semi-metals, incorporates them into the same compound. From hence arises a difference in the contents of these different mixtures; and from this difference, people, who have not sufficient experience, form to themselves

[*d*] The ore of nickel must be subjected to roasting, in order to obtain its regulus: and, during this operation, a great quantity of sulphur and arsenic, greater or less, according to the quality of the ore, is expelled; so that it sometimes loses upwards of half its weight, but frequently not above 0,3. This ore, though long and compleatly calcined, does not always acquire the same colour: but in general becomes *greener*, in proportion as it is more rich. Sometimes, especially if suffered to lie at rest, its upper surface

selves false notions of the whole compound, and of each part contained in it. For which reason they chuse rather to retain that definition of the Kupfernicksel which has received its sanction from the earliest authors, than to admit the conclusion to which Mr. Cronstedt's experiments seem to lead.

For my own part, I have found myself obliged to follow the opinion of the latter, partly because I am tired with those common epithets given to unknown bodies; such as, *wild, refractory, rapacious, arsenical, irreducible, metallic earth*, &c. which regard the effect alone and not its cause; and partly because I have not, besides the nickel, found any metal or metallic composition, which

1. Becomes green when calcined.
2. Yields a vitriol, whose colcothar also becomes green in the fire.
3. So easily unites with sulphur, and forms with it a compound of such a peculiar nature, as the nickel does in this circumstance; and that
4. Does

face is covered with green vegetations, somewhat of the form of thin corals, which are hard and sonorous.

Let a double or triple quantity of *black flux* be added to the roasted powder, and the mixture well fused in a forge, in an open crucible, covered with common salt, according to the usual method. The vessel being broken, a metallic globule is found at the bottom, under the scoræ, which are *brown* or *black*, or sometimes even *blue*. The weight of the globule amounts to 0,1, or 0,2; or, at most, to 0,5 of the crude ore.

This, however, is far from being pure; for although the roasting be ever so violent and long continued, yet a considerable quantity of *sulphur*, and especially *arsenic*, still remain concealed

4. Does not unite with silver, but only adheres or sticks close to it, when they have been melted together.

The nickel not having yet been found free from cobalt and iron, is the reason why it was not discovered. This was the case also with the cobalt. Platina del pinto perhaps, in the same manner, might for a long time have been mixed in the gold, at certain places, where it is said to be naturally paler than any where else in the world. But the existence of such things cannot any longer be denied, since the method is discovered to obtain them separate, and free from heterogeneous substances. It would be the same thing indeed, as if in a country where silver is never found but in the potter's lead ore, any person should deny

cealed in the regulus, exclusive of the *cobalt* and a great proportion of *iron*, which last is generally so prevalent as to make the *regulus magnetic*, unless this semi-metal itself possesses this last quality; for it seems stronger in proportion as the *regulus* undergoes other further purifications.

Nine ounces of the same regulus of nickel, that had been eliquated by Mr. Cronstedt, and kept in the Suabian collection of the Upsal Academy, whose specific gravity was ≈ 7.410 , were reduced to powder, and exposed in several dishes, for the space of 6 hours, to an exceedingly vehement heat, under the dome of an assay furnace. By this the arsenic was first dissipated with a *stæid* smell: a sulphureous odour was next perceived: afterwards a quantity of white smoke, was emitted without garlick smell, which probably arose from the sublimation of the more dephlogisticated arsenic: the surface swelled in heaps, and green vegetations sprang out from all the surface, resembling *moß*, or the *fili-form lichen*. There remained at the bottom a powder of a ferrugineous ash-colour, and 0,13 of the substance was dissipated by this operation.

Half

deny the existence of either of these metals, or insist upon it, that one is produced from the other.

It is remarkable, that the precipitates of nickel give a blue colour to the spirit of sal ammoniac, when they are dissolved in it; without shewing any other marks of copper, which, however, could not be concealed, if there were any; for if a small quantity of copper is melted with the nickel, and kept in a strong fire with it, the copper soon separates, and scorifies, tinging the glass first of a reddish brown opaque, and, the fire being further forced, it then makes it transparent and green as usual.

There is no danger attending the encreasing the number of the metals. Astrological influences

Half an ounce of this powder or calx, being fused in a forge for 4 minutes together, with 3 times its weight of black-flux, yielded a regulus, the surface of which was reticulated, all the areolæ being hexangular, with exceeding slender striæ, diverging from a tuberculated center; its weight was ≈ 0.73 of half an ounce; was obedient to the magnet; and when scorified with borax, left a blackish glass.

The roasting was repeated six times, for many hours: and the arsenic was separated by the addition of powdered charcoal; and the reduction being effected with equal parts of *white flux*, *lime*, and *borax*, a regulus was obtained, semi ductile, highly magnetic, and soluble in nitrous acid, which became of a green colour by the solution.

The regulus of nickel being mineralised a third time with sulphur, and reduced by powder of charcoal, produced a regulus, whose specific gravity was ≈ 8.666 ; it not only adhered strongly to the magnet, but to any other piece of iron; nay, the small pieces of it attracted one another, and it was so ductile,

fluences are now in no repute among the learned, and we have already more metals than planets within our solar system. It would perhaps be more useful to discover more of these metals, than idly to lose our time in repeating the numberless experiments which have been made, in order to discover the constituent parts of the metals already known. In this persuasion, I have avoided mentioning any hypotheses about the principles of the metals, the processes of mercurification, and other things of the like nature, with which, to tell the truth, I have never troubled myself.

tile, that a globule, whose diameter did not exceed *one line*, was reduced by hammering to a plate of upwards of 3 lines in diameter: it was of a *whitish colour*, mixed with a glittering kind of *red*. The scoria of this regulus were almost always of a *hyacinthine colour*.

The analysis of nickel in the *moist way*, is as yet very imperfect. By solution in the nitrous acid it is freed from its sulphur; and, by adding water to the solution, bismuth, if any, may be precipitated, as may silver if contained in it by the marine acid.

To separate cobalt from nickel, when the cobalt is in considerable quantity, a saturated solution of the roasted ore of nickel is to be dropped into a liquid volatil alkali. The cobaltic part is instantly re-dissolved, and assumes a garnet colour. When filtered, a grey powder remains on the filter, which is the nickel. The cobaltic part may be precipitated from the volatil alkali by any acid.

If the ore be fused with 3 times its weight of *liver of sulphur*, the cobalt will be taken up, and may be separated by lixiviation.

It is highly probable that nickel exists in some species of roof-slates, and in horn-stones, whose solution in spirit of nitre is of a *green colour*. *The Editor from Kirwan and Bergman.*

N. B.

N. B. *Various Authors of some note, among whom stand Messrs. Pabst, Monnet and Romedel 'Isle have asserted that cobalt, nickel, and manganese, are nothing else but either modifications of iron, or compounds of other known substances. But Messrs Cronstedt, Bergman, and lately Mr. Kirwan at the end of his Elements of Mineralogy, have compleatly evinced the fallacy of their arguments, so that no unprejudiced person can entertain any farther doubt to the contrary.* The Editor.

S E C T. 395. (113.)

Manganese. *Manganesum* [a].

It's general properties.

The ores of this kind are in Swedish called *Brunsten*, in Latin *Sydereæ*, or *Magnesiæ nigra*,
in

[a] This kind of ore, commonly called *Black*, or *Glass-makers Magnesia*, is scarcely any thing more than a calx of a new semi-metal. This was, for the first time, clearly described, and its properties admirably investigated and explained by Mr. Scheele in the *Memoirs of Stockholm* for 1774. It was afterwards exhibited in its metallic form by Mr. Gahn; and its properties in that state were described by Mr. Bergman, in the 2d vol. of his works. Since that time it has frequently been produced in its metallic form by Mess. *Morveau* and *Lapourse* in France, and lately here by Mess. *Woulfe* and Dr. *Pearson*, &c.

This

in order to distinguish them from the *Magnesa alba officinalis*, and in French *Manganese*, &c. They are by some lithographists entirely omitted, and by others ranked among the iron ores; but, as I am convinced both by my own experience, and by that of others, that they contain no greater quantity of metal than sometimes two or three per cent. of iron, and sometimes a little tin, I think that the remaining part, which must consequently be considered as a kind of earth, deserves a particular and separate place in a Mineral System, at least until a farther acquaintance with its nature may be obtained: and to this opinion I have been persuaded by its following peculiar qualities:

1. Man-

This regulus is of a dusky white colour, with an uneven and irregular surface, arising from its imperfect fusion. It is bright and shining in its fracture, but soon tarnishes by exposure to air; q. is harder than iron, less fusible, and very little. Its specific gravity is = 6,850

When pulverised it is always magnetic, though large pieces are not so. If exposed to the air, particularly in moist weather; it soon crumbles into a blackish-brown powder, which is something heavier than the regulus.

It is soluble in acids, but most readily in the nitrous. Its solutions are mostly colourless; but that in the nitrous acid is generally brownish, from a slight taint of iron: and there is always a spongy residuum of the nature of plumbago, left undissolved. These solutions afford a white precipitate with aerated acids, which precipitate when heated, and grow black.

This regulus is obtained by mixing the calx, or ore of manganese, with pitch, making it into a ball, and putting it into a crucible with powdered charcoal $\frac{1}{8}$ of an inch thick on the sides, and $\frac{1}{4}$ of an inch at the bottom. Then filling

1. Manganese consists of a substance, which gives a colour both to glasses, and to the solutions of salts, or, which is the same thing, both to dry and to liquid menstrea; viz.
 - a. Borax, which has dissolved manganese in the fire, becomes transparent, of a reddish brown, or hyacinth colour.
 - b. The microcosmic salt becomes transparent with it, of a crimson colour, and moulders in the air.
 - c. With the fixed alkali, in compositions of glass, it becomes violet; but if a great quantity of manganese is added, the glass is in thick lumps, and looks black.
 - d. When scorified with lead, the glass obtains a reddish-brown colour.
 - e. The lixivium of deflagrated manganese is of a deep red colour.

2. It

the empty space with powdered charcoal, covering the crucible with another inverted and luted on, and exposing it to the strongest heat of a forge for one hour or more.

A small piece of the regulus, put into a dry bottle well corked, remained perfect for the space of 6 months; but afterwards exposed to the open air of a chamber for two days, it contracted a brownness on the surface, and became so friable, as to crumble between the fingers. The internal parts, however, retained an obscure metallic splendor, which disappeared in a few hours.

It melts readily with other metals, pure mercury only excepted. Copper united with a certain quantity of it, is extremely malleable; but upon the surface of this mixture, when polished, scarce any traces of the red colour are to be seen. This mixture sometimes, by age, produces a green efflorescence.

Whea

2. It deflagrates with nitre, which is a proof that it contains some phlogiston.
3. When reckoned to be light, it weighs as much as an iron ore of the same texture.
4. When melted together with vitreous compositions, it ferments during the solution: but it ferments in a still greater degree, when it is melted with the microcosmic salt.
5. It does not excite any effervescence with the nitrous acid: aqua regia, however, extracts the colour out of the black manganese, and dissolves likewise a great portion of it, which, by means of an alkali, is precipitated to a white powder.
6. Such colours as are communicated to glasses by manganese, are easily destroyed by the calx of arsenic or tin: they also vanish of themselves in the fire.
7. It is commonly of a loose texture, so as to colour the fingers like foot, tho' it is of a metallic appearance when broken.

S E C T.

When Manganese is melted with salt-petre, the mass, according to Dr. Brunnich, assumes a *green colour*.

Tin very easily unites with manganese; but zinc not without much difficulty, perhaps on account of its volatility and inflammable nature. White Arsenic adheres to it, and by means of phlogiston reduces it to a metallic form.

A mixture of powdered manganese with marine acid, is capable of dissolving gold, if thin plates of it be dipped in the mixture.

S E C T. 396. (Additional.)

Native Manganese. , Manganefium Nativum.

The discovery of native regulus of manganese, was far from being expected by rational mineralogists; for, as Mr. Kirwan observes, of all the metallic substances, manganese is the more ready to lose the proportion of the required phlogiston, for its natural mineralisation: and unless alloyed in native iron, there could be no hopes of seeing such a natural production.

We find, however, an account of this discovery, given by Mr. de la Peyrouse, in the *Journal de Physique*, for January 1786: by which

Manganese, calcined by fire, yields a blackish calx; but if the ignition be continued for 12 days, it acquires a dark-green colour: sometimes also, it produces a white or a red calx. The black calx retains a very small portion of phlogiston, but the white abounds with it so much, that it is soluble in acids.

All these various calces, in a common crucible, by means of a sufficient degree of fire, run into a yellowish red glass, which is pellucid, unless too great a degree of thickness renders it impervious to the rays of light.

The black calx of this semi-metal, when mixed with other substances, attracts phlogiston with peculiar energy, and exhibits several remarkable phenomena both by fire and solution: which may be seen in the Treatise of Bergman upon the *White Grey calx of Iron*. The Editor from the same Author, and from Kirwan.

which it is evident that the manganese does naturally exist in the bowels of the earth. The following are its remarkable properties.

1. Its external appearance, colour, and figure are the very same as those of the artificial regulus of manganese.
2. It likewise soils the fingers when handled.
3. Its substance is quite pure, having no particles that are in the least attracted by the magnet.
4. Its texture is lamellated, and the lamellæ seem to affect a kind of divergence among themselves.
5. It has the very same metallic brilliancy, as the artificial manganese.
6. It has also a partial malleability: and, when repeatedly hammered,
7. It exhibits a kind of exfoliation, forming itself into very thin leaves.
8. Its opacity and density is so compleatly similar to that of the artificial regulus, that was it not for the natural matrix in which it is imbedded, it could not be at all distinguished from it.
9. This ore is not found in large masses, or in a solid continued body, but only in lumps, and unconnected clots, inclosed and intermixed with the powdery manganese ore.
10. These lumps are somewhat flattened, or compressed in their figure, like the artificial ones, though they are of a larger size for the most part.
11. And this powdery manganese ore, in which the reguline lumps are imbedded, has an ar-

gentine hue, which seems to countenance the suspicion of its having been acted upon, by the violent heat of some natural deflagration on the spot.

This new manganese ore was found among the iron mines of *Sem*, on the valley called *Viedersos*, in the county of *Foix*, near the Pyrenean mountains.

S E C T. 397. (114.)

Native Calces of Manganese.

Manganese is found [*b*],

A. Loose and friable, *Manganesium friabile terreum*.

a. Black, seems to be weathered or decayed particles of the indurated kind, from England.

S E C T.

[*b*] The aerial acid is the only mineralizer of Manganese in its dry state; and, according to the different degrees of the phlogistication of this semi-metal, it forms calces of different colours and different properties. It is to be understood, that when manganese is as much phlogisticated as it can be, without being in a reguline state, it forms a *white calx*, which contains a large portion of *fixed air* (about 40 per cent.) which enables it to retain phlogiston, because the compound of acid and calx, attracts phlogiston more strongly, than either does singly. In proportion, therefore, to its dephlogistication,

S E C T. 398. (115.)

*White and Red Manganese.***B.** Indurated, *Manganese indurata.*

1. Pure, in form of balls, whose texture consists of concentric fibres, *Manganese pura sphaerica radiis concentratis.*
- a. White [c], *Manganese alba strictè sic dicta*, is very scarce. I have seen a specimen of this

gification, and its union with other substances, its colour is either *blue, green, yellow, red, brown, or black.*

The *blue* is that which it acquires from the proportion of phlogiston it is enabled to retain, by reason of its union with fixed alkalies. The *green* arises from a mixture of the *blue*, with the *yellow* calx of iron. *Yellow* always arises from the prevalence of the calx of iron. *Red* from a slight phlogification of that calx: and *black*, from its thorough dephlogification.

Yet, if the *black* calx be long roasted, it becomes *green*, which is thought to arise from the expulsion of the *fixed air*, which leaves its phlogiston with the manganese, and thus produces a *blue*, which, mixed with the *yellow* calx of iron, becomes of a *green* colour. The *brown* arises from a mixture of the *red* and *black* calces. All this note was extracted from *Scheele's Dissertation* on the subject, by *Kirwan*.

[c] This contains but a very small proportion of iron. It was found by Mr. Rinman both in small white crystals, and in round masses, on the cavities of quartz, and adhering to glanz blend. It is rather less hard than lime stone.

It is of a sparry texture, and

Scarcely magnetic, even after roasting.

Is soluble with efflorescence in *nitrous acid*; and

this kind in a collection from an unknown place in Norway; and by examining a piece of it, I found that it differed from the common manganese, by giving to borax a deep red colour in the fire: this sort acquires a reddish brown colour when it is calcined.

b. Red manganese [d] is said to be found in Piedmont. This I have never seen; but

Affords a colourless solution, from which with mild alkalis separates a white precipitate; and this, when heated, presently grows black; a sure criterion of being a true manganese.

Mr. Lapeirouse found this white ore in the form of a spongy efflorescence, vegetating on the surface of some iron-ores, particularly on *hæmatites*.

Mr. Rinman found it also in the form of calcareous spar, of the colour of rosin, and somewhat shining, covered over, in some places, with a sooty powder; and in thin pieces transparent at the edges, but not hard enough to strike fire.

Nitrous acid dissolves it almost entirely; with mild alkalis the solution affords a white precipitate, which becomes black when heated.

It consists of *manganese* bedded in zeolite. It melts *per se* with the blow pipe into a whitish grey porous slag; and, with the addition of calcined borax, gives a garnet colour to glass.

Many of the white sparry iron ores may also be classed among the ores of manganese, as they contain more of it than of iron. *Kirwan*.

[d] Red manganese contain less *fixed air*, and is accompanied with more iron than the preceding ore: and also with calcareous or ponderous earth; or barytes, and flint.

It is found either loose and semi-indurated in a matrix of calcareous spar; or on talky schistus; or on *hæmatites*, and other iron ores; or in heavy hard masses of lamellar, radiated, or equable texture; or crystallized in pyramids, rhomboids, or short brittle needles. *The Editor from Kirwan. See the note [c] to the next Section.*

I have

I have been told by an ingenious gentleman, that this variety is free from iron, and gives rather a red than a violet colour to glafs,

S E C T. 399. (116.)

Black Manganefe.

2. Mixed with a small quantity of iron,
Manganefia parum martialis.
- a. Black manganefe, with a metallic brightness. This is the most common kind, and is employed at the glafs-houfes, and by the potters [e].

It

[e] 1. There are feveral varieties of this ftone in the mountains round Bath, called *Mendip-hills*, of which the Bristol potters confume great quantities. *Brunnich.*

2. The *black* ore of Manganefe differs but little from the *brown* ones; and they are both found either cryftallized in the fame form as the *red-ores*, or in folid mafles, fome of which have a metallic appearance; others are dull, earthy, and mixed, or embodied in quartz, or in a loofe earthy form.

3. Their fpecific gravity is about $\approx 4,000$.

Both, particularly the *brown* and the *red*, are folvable in fome meafure by digeftion in *oil of vitriol*: the folution is at firft reddifh, but afterwards becomes colourlefs, unlefs they contain a large proportion of iron.

4. But neither the *Dephlogifticated nitrous acid*, nor the concentrated *vitriolic acid*, aft upon them, unlefs *fugar*, *boney*, *gum*, or other fimilar *fubftance* be added; for then the folution will be promoted and compleated. This proceeds, as Bergman remarks, from the exhausted ftate of the calx,

It is found,

1. Solid, of a flaggy texture, *Manganesa textura vitrea*, from Skidberget, in the parish of Lekfand, in the province of Dalarne.

2. Steel

calx, which has not phlogiston enough to be acted upon by the acid, unless these substances furnish the calx therewith.

5. If this calx is boiled with a solution of sugar in water, it is not supplied with phlogiston; and on being separated by lotion, remains insoluble as before. But if an acid be also added, by the help of it, a translocation of the phlogiston then takes place, and the calx by its means takes up as much phlogiston as to be rendered soluble; nay, the phlogisticated vitriolic acid, when poured upon this calx, soon loses its smell, and dissolves it readily without any assistance.

6. The solution, just now mentioned, either by the dephlogisticated nitrous, or by the concentrated vitriolic acid, is colourless; and, with mild alkalis, affords a white precipitate of the same nature as that already mentioned, N^o 3.

7. These calces, the *black* and *brown*, contain more iron and less fixed air, than the *red* and *white* ones, already spoken of.

The Perigord stone, Lapis Petracorius.

8. To the last variety of black manganese belongs the true *Perigord stone*; which is of a dark grey colour, like the *basaltes* or *trapp*. It may be scraped with a knife, but it is difficultly broken. Its structure is amorphous, very compact, heavy, and as black as charcoal. It has a glittering appearance of a striated kind, like the antimonial ore: and its particles are disposed in the form of needles, crossing one another without any agglutination, inasmuch that some are loose in the same manner as iron filings when stuck to a loadstone; upon the whole they resemble the scoria from a black smith's furnace.

9. This substance, when calcined, becomes of a reddish brown colour, and harder; but is not magnetic. Its specific gravity

2. Steel grained, also from Skidberget.
3. Radiated, *Radiata*, also from Skidberget, and Tiveden, in the province of Ostergottland.
4. Cristallised.

a. In

gravity is considerable. It does not melt *per se*; but with borax it affords an amethyst-coloured glass. Nitrous acid scarcely acts on it, without the addition of sugar. This stone seems also to contain argill, and some portion of iron.

10. It is found in Gascony and Dauphiny, provinces of France, and in some parts of England. The French potters and common enamellers employ this substance sometimes in the glassy varnish of their earthen wares, &c. *The Editor from Kirwan and Bomare.*

Blackwadd.

11. This substance is found in Derbyshire, and is one of the most remarkable ores of manganese. It is of a dark brown colour, partly in powder, and partly indurated and brittle. If half a pound of it be dried before a fire, and afterwards suffered to cool for about one hour, and then 2 ounces of linseed oil be gradually poured on it, mixing the whole loosely like barm with flour, little clots will be formed: and in something more than half an hour, the whole will grow hot, and at last burst into a flame. The temperature of the room where this experiment was repeated, was about 30 *deg.* of Fahrenheit; and the heat this ore was exposed to while drying, might be about 130 *degr.*

12. According to Wedgwood's analysis, 100 parts of *blackwad* contain 43 of manganese, as much of iron, 4,5 of lead, and near 5 of micaceous earth. *The Editor from Kirwan.*

Manganese in vegetables.

13. Manganese seems to be contained in the ashes of most vegetables; and to it the blue and greenish colour of calcined vegetable alkali is owing. These colours are generally attributed to the phlogiston of the alkali; but if so, they should

not

- a. In form of coherent hemispheres, *Hemisphaeritis continuis*, from Skidberget in Leksand.

S E C T. 400. (118.)

OBSERVATIONS ON MANGANESE [f].

Though it may seem difficult to many, to distinguish the kinds of manganese by their appearance,

not be found in fixed nitre, as the nitrous acid should carry off, during its decomposition, all the phlogiston. Yet this alkali is always greenish, so that the colour seems to arise from the ashes of the charcoal with which the nitre was decomposed.

If 3 parts of the alkali of tartar, 1 of sifted ashes, and $\frac{1}{2}$ of nitre, be melted together, they form a dark green mass, which being dissolved in water, affords a beautiful green solution; and this being filtered, on the addition of a few drops of oil of vitriol, becomes *red*; and after a few days a brown powder is deposited, which has the properties of manganese. The ashes of serpyllum contain very little of it. Those of trees contain most. *The Editor chiefly from Bergman and Kirwan.*

[f] For reducing almost all the metallic-ores, some kind of fluxes are to be employed according to their kinds and circumstances: but manganese has no need of any flux at all, requiring only to be exposed to a quick and very violent heat at once; and such is its propensity towards vitrification, that the regulus never can be reduced to a single mass, but it is generally formed into various small lumps, dispersed between the remaining calces, as Mr. de la Peyrouse observes.

To analyse the above-mentioned ores of manganese, they should be first roasted, to dephlogisticate the calx of the semi-metal, and the iron, if any is there contained. They are

appearance, or external marks; yet it is extremely easy to know them by experiments made in the fire, if attention is had to the above-mentioned phenomena (Sect. 395.). From hence it is not difficult to comprehend why manganese has hitherto been either omitted, or erroneously ranked in systems, viz. because it has, like many other mineral bodies, been examined only by sight, while the more troublesome method of examining it in the fire, has been overlooked.

Some might perhaps imagine the manganese to be the residue of some metal, which cannot be reduced again into its metallic state; but it ought to be remembered, that no metal can, by any means yet known, be brought to an absolutely irreducible earth or calx, unless perhaps by the burning-glass: and therefore there is no reason to suspect that nature affords such a production. Ignorance and idleness have invented certain terms or expressions, to avoid

are then to be treated with dephlogisticated nitrous acid, in order to dissolve the earths. The residuum should then be treated with nitrous acid and sugar, by which means a colourless solution of manganese will be obtained; which, being precipitated by aerated mineral alkali, will afford a precipitate, 100 gr. of which are equivalent to as many of the regulus of manganese.

Many species of iron contain also manganese: and to discover it, let the iron be dissolved in an acid, and precipitated by the Prussian alkali; let the solution be poured off, and the precipitate digested in pure water. The Prussian manganese will be dissolved, and the Prussian iron will remain undissolved.

Otherwise, if a small piece of the ore be heated white in a crucible, and 5 times its weight of purified nitre be projected

avoid giving an account of those ores or mineralisations, which are not easy enough to be decomposed; for instance, *wild, rapacious, arsenical, volatile, &c.* and some iron ores in particular have been thus called; by which means it has happened, that æconomical reflections have often been added to natural and philosophical descriptions: and thus others are deterred from examining many bodies, of which we have acquired, and still retain false notions arising from this way of proceeding.

The manganese has by systematists been commonly ranked among such iron ores; but the artificers who make use of it in the manufacture of glass do not look upon it as such; nor can they by any means be persuaded to use any of the pretended bodies akin to it, instead of the manganese itself, for experience prevails more with them than suppositions. The consumption of manganese is but small, and therefore it is not a very profitable article.

on it, taking care that no coal or ashes should get into the crucible; when all is cold, the upper part of the crucible will be covered with a *greenish* or *bluish* crust, if the iron contains manganese. When the solution of the iron, in the marine acid, is of a *red* colour; this also denotes the presence of manganese, though this colour soon changes to a *yellow*, by acquiring phlogiston from the martial part.

Manganese is of great use in the manufactory of glass and crystal, to deprive them of their green colour, which they would otherwise retain. Potters also make a great use of it for the glass-varnish of their earthen and porcelain ware. But modern chemists employ it for other interesting purposes, such as to dephlogistate various menstrea for delicate processes, &c. *The Editor from Bergman and Kirwan.*

- S E C T.

S E C T. 401. (*part of Sect. 154.*)

Molybdena. *Molybdena*, Lat. *Blyertz. Wafferbleij*, Sw. *Wafferbley. Reifferbley*, Germ. *Molybdena*, French.

- a. Lamellar and shining, of the same colour as the potters lead ore. *Molybdæna pura membranacea nitens* [a].

From

[a] This substance resembles the plumbago of Sect. 231, and has long been confounded with it, even by our Author; but,

1. Its laminæ are larger, brighter: and, when thin, slightly flexible. They are of an hexagonal figure.

2. It is of a lead colour, and does not strike fire with hard steel.

Its specific gravity is = 4,569, according to Kirwan; and 4,7385, according to Briffon.

4. When rubbed on white paper, it leaves traces of a dark brown or bluish colour, as the plumbago or black lead does; but they are rather of an argentine gloss, by which circumstance the Molybdena, according to Dr. d'Arcet, may be easily distinguished from black lead, as the traces made by this last are of a darker hue, less brilliant, and of a deeper tinge.

5. In an open fire it is almost intirely volatil, and infusible. Microcosmic salt, or borax, scarcely affect it; but it is acted upon with much effervescence, by mineral alkali, and forms with it a reddish mass, which smells of sulphur.

6. It is affected by no acid but the nitrous and arsenical, both of which require the assistance of heat; the latter is converted into orpiment by it.

7. It consists of an acid of peculiar nature (described in Sect. 162), united to sulphur. A small proportion of iron is commonly found in it, but this seems merely fortuitous:

From Bispergs Klack in the province of Dalarne, Bastnas-grufva at Riddarshyttan in Westmanland, Altenburgh in Saxony.

The variety from Bispergs Klack has been examined by Mr. Quist, and has, by its volatilising under the muffle, in form of a white fibrous

100 parts of molybdena contain about 45 of this acid, and 55 of sulphur.

8. It is decomposed either by detonation with nitre, or by solution in nitrous acid; the latter method is the readiest. For this purpose it is to be five times distilled, each time with four times its weight of spirit of nitre: a white calx at last remains, which is the molybdenous acid.

9. This acid is soluble in 570 times its weight of water in the temperature of 60; the solution reddens that of litmus, precipitates sulphur from the solution of liver of sulphur, &c. The specific gravity of the dry acid is 3,460. 3 *Bergm.* p. 127.

10. This acid is precipitable from its solution in water by the *Prussian* alkali, and also by tincture of galls: the precipitate is reddish brown.

11. If this acid be distilled with three times its weight of sulphur, it re-produces molybdena.

12. The solution of this acid in water unites to fixed alkalis, and forms crystallizable salts; as it also does with calcareous earth, magnesia, and argil; these last combinations are difficultly soluble; it acts also on the base metals, and with them assumes a bluish colour.

13. This solution precipitates silver, mercury, or lead, from the nitrous acid, and lead from the marine, but not mercury.

24. It also precipitates barytes from the nitrous and marine acids, but no other earth. Molybdenous baroselenite is soluble in cold water.

15. This acid is itself soluble in the vitriolic acid by the assistance of heat; and the solution is blue when cold, though colourless while hot; it is also soluble in the marine acid, but not in the nitrous.

-16. Molybdenous

fibrous sublimate; induced that gentleman to examine the black lead more particularly. He has published some very remarkable experiments on it in the Transactions of the Academy of Sciences at Stockholm, for the year 1754.

16. Molybdenous tartar and ammoniac precipitate all metals from their solutions by a double affinity. Gold, sublimate corrosive, zinc, and manganese, are precipitated *white*; iron, or tin, from the marine acid, *brown*; cobalt, *red*; copper, *blue*; alum and calcareous earth *white*. *Scheele Mem. Stock. 1778.*

17. This acid has been lately reduced by Mr. *Hierm*, but the properties of the regulus thus obtained are not yet published.

18. Mr. Pelletier obtained also the regulus of molybdena, by mixing its powder with oil into a paste, and exposing it with powdered charcoal in a crucible, to a very violent fire for two hours. By this process he obtained various globules or beads of regulus, which he found to have the following properties: 1. It may be deprived of its phlogiston by calcination, and reduced to a calx more or less white: 2. It detonates with nitre on the fire, and a combination of the calx with the alkali remains behind: 3. with nitrous acid, it becomes calcined into a white calx: 4. in the dry way treated with alkalis, it produces inflammable air: 5. it unites with metallic substances, forming as many alloys: 6. and treated with sulphur, regenerates mineralized molybdena.

19. This semi-metal being urged by a strong fire for an hour, produces a kind of silvery flowers, like those of Antimony,

20. It is said that molybdena is soluble in melted sulphur, which seems highly probable, as sulphur is one of its component parts.

Molybdena is found sometimes along with Tin ores, and Iron ores, that are attracted by the magnet, among copperish pyrites; and also with Wolfram, not only in Saxony, Iceland, France, but in Spain, Sweden, &c. *The Editor, from Kirwan, Scheele, Pelletier, &c.*

S E C T. 402. (117.)

Wolfram. Wolfranum, Spuma Lupi, Lat.

This mineral has the appearance of Manganese, blended with a small quantity of iron and tin, *Manganesia, parva cum portione martis et jovis mixta: Spuma Lupi, or Wolfram* [b].

1. With

b. 1. This mineral, which the Germans have called *Wolfram*, or Wolfrath, a name translated into Latin *Spuma Lupi*, or rather *Lupus Jovis*, has been met with hitherto only in mines of tin; for, though many authors would make it more common, it is an error owing to their confounding some glossy iron-ores with the true Wolfram, as appears by the specimens which are frequently found in Cabinets under this name. It has been on account of the bad effects produced by this mineral in the smelting of tin-ores, from which it is very difficult to separate it by washing, because of its great specific weight, that the names of *Spuma Lupi*, *Lupus Jovis*, and *Wolfram*, have been given to it, by the miners and smelters.

2. This is really a metallic ore, and contains the very semi-metal lately discovered in the *Tungstein* of Sect. 27: both being mineralized, or rather formed by the same *Tungstenic* acid, already described in Sect. 263. And having treated already in these two Sections of both, it only remains now to speak of the *Wolfram*.

3. This metallic ore, which is generally found in tin mines, as before said, is of a black or brown shining colour, of a radiated or foliated texture, of a moderate hardness, and sometimes so brittle as to be easily broken between the fingers; but it is very weighty, since its specific gravity is = 7,119.

4. When

1. With coarse fibres.

- a. Of an iron colour, from Altenberg, in Saxony. This gives to the glass compositions,

4. When scratched it shews a red trace, and this distinguishes it from the Tungstein of Sect. 27, which is a variety of the ore of the same semi-metal.

5. It is found in scattered masses, crystallized into hexædral flat prisms, coming to a point, with 4 sides, and these points terminated obliquely.

6. Internally it is shining, with the lustre almost of a metal.

7. When it is broken, its texture appears leafy; and the leaves are flat, but somewhat confused;

8. On some sides they are unequal, and very seldom striated.

9. It is always opaque; and when scraped, it yields a powder of a dark reddish grey.

10. The Wolfram will not melt by itself with the blow-pipe: the angles being only rounded; but

11. Internally it preserves its structure and colour without change.

12. With microscomic salt it fuses with effervescence; and forms a glass of a pale red in the exterior flame, and much darker in the interior.

13. With borax it likewise effervesces, and forms by the interior flame a glass of a greenish yellow, which by the exterior turns reddish.

14. Being exposed in a crucible to a strong fire for one hour, it swelled, became spongy, and of a brownish colour; entered into a semi-vitrification; and was attracted by the magnet.

15. Equal parts of nitre and wolfram being put in a red-hot crucible, they detonated, or rather boiled up with a blue flame round the edges; and a nitrous vapour arose: the matter, when cold, on being put into water, partly dissolved: and a few drops of acid produced a white precipitation.

16. Pounded Wolfram, digested in a sand-heat with a sufficient quantity of marine acid, to the depth of the thickness

tions, and also to borax and the microcosmic salt, an opaque whitish yellow colour, which at last vanishes.

ON

of a finger above the matter, after one hour's boiling, the powder turned yellow; which is the same phenomenon as happens with the tungstenic acid of Sect. 163.

17. It appears by the chemical analysis of Wolfram made by Messrs. John and Faust de Luyart, that its contents consist of 22 parts of manganese in the state of black calx; 13,5 of iron, 65 of a yellow wolfranic calx, and of quartz and tin.

18. A good quantity of this yellow calx being collected, it was observed that it was entirely insipid, and that its specific gravity was $\approx 6,120$. It effervesces with microcosmic salt: produces a transparent blue colour without any shade of red; and effervesces also with borax, and with mineral alkali. This same matter does not dissolve in water; but when triturated with it, forms a kind of emulsion; to which the acetous acid gives a blue colour, but does not dissolve it. This matter, however, dissolves completely in caustic vegetable alkali, both by the *dry* and *moist way*; and the liquor acquires a great bitterness. By pouring on it some nitrous acid a precipitate ensues, which leaves on the filtre a white salt; and this being welledulcorated, has a taste at first *sweet*, afterwards *sharp* and *bitter*, producing a very disagreeable sensation on the throat. It is in fact a true acid combined with a portion of the alkali and precipitating acid.

19. This acid melts, if alone, by the flame urged with the blow-pipe.

20. This white salt is a true metallic triple salt, as appears by putting 100 gr. in a crucible with powdered charcoal; for after one hour and a half of a strong fire, when cooled a button was found, which fell to powder between the fingers. Its colour was brown; and, on examining it with a magnifier, there was a congeries of metallic globules, of the bigness of pin's heads; which, when broken, exhibit the metallic appearance, of a steel colour in the fracture: and their specific gravity was $\approx 17,600$.

21. These

ON THE SIDERITE.

The supposed new metal, named Siderite, was first discovered by Mr. Meyer of Stetin. But Professor Bergman and Mr. Kirwan (besides various other chymical and mineralogical philosophers) soon applied themselves to investigate the properties of this substance, till at last the same discoverer, Mr. Meyer, happily ascertained by the synthetic method, that it was nothing else but a natural combination of the phosphoric acid with iron; and published an account of his mistake. This very combination, however, is an important discovery in nature, and the knowledge acquired by the investigation of its properties, is a very valuable acquisition to the common stock of modern discoveries. The words of the same ingenious philosopher, the inventor, may

21. These metallic globules, melted with other metals, gold and platina excepted, afford ductile alloys with silver or copper; and hard ones with cast iron, tin, antimony, bismuth, and manganese.

22. It is therefore evident that this is a new metal before unknown, as it is evinced, 1. by its specific gravity, equal to 17,600: 2. by the tinges it gives to different glasses: 3. by its great difficulty to fuse, which is greater than that of manganese: 4. by the yellow colour of its calx: 5. its alloys with other metals: 6. its insolubility, at least by a direct method, with mineral acids: 7. its easy solution in alkalis: 8. the emulsion it gives with water: 9. and by the blue colour it gives to acetous acid. All these properties are sufficient to demonstrate that this Wolfranic substance is a metal *sui generis*, distinct from all others. *The Editor, chiefly from the Chemical analysis of Wolfram, by Mess. de Luyart.*

K k k 3

serve

serve to shew this: what a plentiful source, says he, of phosphoric acid would be opened to us, if it were but easy to separate! The close combination of this acid with iron, is also very remarkable.

Mr. Klaproth of Berlin, by a remarkable coincidence, came to the very same conclusion, without any communication with Mr. Mayer. He did not attempt to establish his opinion by analytical experiments, as he conceived that it would be difficult to separate the iron and the acid, either by phlogiston or any other way. He found, however, the artificial compound of phosphoric acid and iron, to agree in its properties with the calx sideri alba, obtained by Bergman and Mayer from the cold-short iron, which is extracted from the swampy or marshy ores, described at p. 732. The native Prussian blue iron ore, of Sect. 341, which is extracted from similar ores, contains also the same combination of the siderite in a much larger portion. The Editor from Bergman, and his English Translator.

ON THE SATURNITE.

Mr. Kirwan gave this name to a supposed new metallic substance, announced by Mr. Monnet, as found in the lead-founderies of Poullaouen in Brittany, where it is separated from the lead ore, during its torrefaction. It is described as resembling lead in its colour, specific gravity, solubility in acids, and other similar qualities to those of lead: excepting only that it is more fusible,

fusible, very brittle, easily scorified and volatilized; and not miscible with lead, when in fusion.

But Mess. Hassenfratz and Giroûd have demonstrated, both by the analytical and synthetical methods, that this very metallic substance, the saturnite, which was formerly neglected, but which is now kept for useful purposes at the said founderies of Poullaouen, is nothing but a simple mixture or alloy of various metals, which separates of itself, on account of its greater fusibility, whilst the lead-ores are roasting in the furnace.

The following table is extracted from Journal de Physique, for January 1786, p. 63, and shews the names and respective quantity of each metal that is generally combined in the saturnite. It is easily conceived, that they must often vary, according to the different ores that happen to be roasted at every time in the furnace.

	lb.	oz.	gros.	grains.
Lead	40	13	6	6
Copper	31	4	0	0
Iron	4	1	2	0
Silver	0	2	1	66
Sulphur	23	10	6	0
The Sum	100	0	0	0

There will be no difficulty in reducing these French weights into the English, by taking notice of the following circumstances:

*1st, that the French pound, or livre of two grains.
marks, contains 9216
K k k 4 and*

- and is divided into 16 ounces, each containing 576 grains
 or into 128 drams (or gros), each weighing 72 grains
 2dly, that the proportion of the French pound weight to the English, called avoirdupois, is, according to Pauçon's Metrologie, as 10000 : 0,92 4.
 3dly, that in consequence of this proportion, this last (the English pound, avoirdupois) is equal to 8537, 7024 French grains
 4thly, But as the same English pound contains only 7000 English grains; it follows, that, these English grains are greater than the French ones, in the proportion of 85 (or 85,38) to 70; so that 85 French grains are equal to 70 English ones. The Editor.

It appears, however, by the *Journal de Physique* for March following, p. 169. that M. Monnet does not admit that the Saturnite, analysed by Mess. Hassenfratz and Giroûd, is of the same kind as that discovered by him; and he adds, that on his having recourse again to the Mines of Poullaonen, in 1783, his new metal was not to be found. We can only add, that this is a most singular disappointment!

APPENDIX,

A P P E N D I X.

S E C T. 403. (259.)

I N T R O D U C T I O N.

I Have already in the preface mentioned the reasons why the Saxa and Fossils commonly called *Petrefactions* cannot be ranked in a Mineral System: and I am persuaded, that the same reason which has prevailed on me, will likewise after mature consideration be approved by others. In the mean time, since these bodies, especially the latter, occupy so considerable a place in most Mineral Collections, and the former must necessarily be taken notice of, by the miners, in the observations they make in the subterranean geography, I would not entirely omit them here; but have endeavored to put them in such an order as may answer that purpose, for which Miners and Mineralogists pay any regard to them.

S E C T.

S E C T. 404. (260.)

The FIRST ORDER,

S A X A. P E T R Æ.

I divide these into two kinds.

1. Compound Saxa, *Saxa composita*;

Are stones whose particles, consisting of different substances, are so exactly fitted and joined together, that no empty space, or even cement, can be perceived between them; which seems to indicate, that some, if not all, of these substances have been lost at the instant of their union.

2. Conglutinated stones, *Saxa conglutinata*,

Are such stones whose particles have been united by some cementitious substance, which, however, is seldom perceivable, and which often has not been sufficient to fill every space between the particles. In this case the particles seem to have been hard, worn off, and in loose, single, unfigured pieces, before they were united.

S E C T. 405. (261.)

1. Compound Saxa, *Saxa Composita*.

A. *Ophites*. Scaly limestone with kernels or bits of serpentine stone in it, *Saxum*

compositum particulis calcareis et argillaceis.

1. *Kolmord marble.* It is white and green.
2. *Serpentino antico*, is white, with round pieces of black steatites in it. This must not be confounded with the *Serpentino verde antico*, of Sect. 409.
3. The *Haraldsö marble*. White, with quadrangular pieces of black steatites.
4. The *Marmor Pozzevera di Genova*. Dark green marble, with white veins.
This kind receives its fine polish and appearance from the serpentine stone.

S E C T. 406. (262.)

B. Stellsten or Gestellstein. *Saxum compositum particulis quartzosis & micaceis.* Granitello.

1. Of distinct particles, *Particulis distinctis.*

This is found at Garpenberg in the province of Dalarne. It is likewise met with in the other mineral mountains of Sweden. In some of these the quartzose particles predominate, and in others, the micaceous. In the last case it is commonly flaty, and easy to split.

2. Of particles which are wrapt up one in another, *Particulis quartzosis micâ convolutis.*
 - a. Whitish grey, from Morthernberget in Norberke in Dalarne.
 - b. Greenish, at Salberg in Westmanland.
 - c. Reddish, from the parish of Malung in Dalarne.

Both

Both these kinds of Stellsten are, for their resistance to the fire, employed in building furnaces; but the latter is the best, because it seems at the same time to contain a little of a refractory clayish substance. The reddish from Malung however cracks very soon, if the flat side of the stratum, instead of the extremity, is turned towards the fire. It is also of great use in mills, if the other or fellow-stone is made of the mill-stone from Arfunde, which is a Saxum of the conglutinated kind, or a coarse sand-stone. It is fortunate for economical purposes, that the plates of these stones are so thick, although thereby they are not so easily split.

S E C T. 407. (263.)

C. *Norrka* and *Murksten* of the Swedes, *Saxum Compositum, micā, quartzo, et granato.*

1. With distinct garnets or shirls, *granatis distinctis crystallisatis.*

a. Light grey, from Selbo in Norway.

b. Dark grey, with very small garnets, from Quarnberget in the parish of Soderli in the province of Jemteland.

c. Dark grey, with prismatical, radiated, or fibrous cockle or shirl, from the village of Handol, in the parish of Are in Jemteland.

2. With kernels of garnet stone, *Particulis granatis indeterminatis.*

3

a. Of

- a.* Of pale red garnet stone, from Stollberget in Norberke in Dalarne.

The first of this kind, whose flaty strata makes it commonly easy to be split, is employed for mill-stones, which may without difficulty be accomplished, if sand is first ground with them, because the sand wears away the micaceous particles at the surface, and leaves the garnets prominent, which renders the stone fitter for grinding the corn.

S E C T. 408. (264.)

D. The Whetstone, *Cos. Saxum compositum micā, quartzo, et forsan argillā martiali in nonnullis speciebus.*

1. Of coarse particles, *Particulis distinctis.*
 - a.* White, from Wanga in the province of Skone.
 - b.* Light grey, from Tellemarken in Norway.
2. Of fine particles, *Particulis minoribus.*
 - a.* Liver brown colour, from Selbo in Norway.
 - b.* Blackish grey, from Lerwik in Hellefors in Westmanland, and from Cologne in Germany.
 - c.* Light grey, from Hellefors in Westmanland.
 - d.* Black. The table slate, or that kind used for large tables, and for school-slates.

The

The naked eye, and the magnifying glass much better, discovers the micaceous particles in this kind to be as it were twisted in one another. Some clay seems likewise to enter into the composition. However, it cannot yet be certainly asserted, that it is real mica which has that appearance in this kind.

3. Of very minute and closely combined particles, *Cos particulis constans impalpabilibus durus*. The Turkey stone [a].

This is of an olive colour, and seems to be the finest mixture of the first species of this genus. It is found in loose stones at Biorlkoginas in the parish of Hellefors in Westmanland, though not perfectly free from cross veins of quartz, which always are in the surface of the rock, and spoil the whetstones. It is also said to be found in Tellemarken in Norway. The best sort of this comes from the Levant and is pretty dear. The whet-stone kinds, when they split easily, and in thin plates, are very fit to cover houses with, though most of them are not of such qualities.

N. B. *The Sect. 265. in which the Author described the Telgstein, has been placed among the Magnesian earths, in Sect. 61. p. 104. to which it properly belongs.* The Editor.

[a]: See Sect. 126, where this stone is fully described. The Editor.

SECT. 409. (266.)

F. Pophyry, Porphyrites. Italorum Porfida Saxum compositum jaspide et felsparato, interdum mica et basalte [b].

- a. Its colour is green, with a light green felspar, *Serpentino verde antico*. It is said to have been brought from Egypt to Rome, from which latter place the specimens of it now come.
- b. Deep red, with white felspar, from Italy, and Egern in Norway.
- c. Black, with white and red felspar, from Klitten, in the parish of Elfdalen in Dalarne.
- d. Reddish brown, with light-red and white felspar, from Hykieberget in Elfdalen, and Gustavstom, in the parish of Gofborn in the province of Wermeland.
- e. Dark grey, with white grains of felspar also from Gulavstom.

Many varieties of this kind, in regard to colour, are found in form of nodules or loose stones in Sweden; but I have only mentioned the hardest and finest of those which are found in the rocks; because, besides these, there are coarse porphyries found, which scarce admit of any polish. The dark red porphyry has been most employed for ornaments, in building, &c. yet it is not the only one known by the name of *Porfido*, the Italians applying the same name also to the black kind.

SECT.

[b] Under the name of *Porphyry*, or *Porfido* of the Italians, both Mr. de Saussure and Mr. Kirwan reckon those stones, which contain either *felspar*, *quartz*, *shorl*, *mica*, with other species of stone of a crystalline form, in a *siliceous*, or even *calcareous*

S E C T. 410. (267.)

G. The *Trapp* of the Swedes. *Saxum compositum jaspide martiali molli, seu argillâ martiali induratâ. . . . [d].*

This kind of stone sometimes constitutes or forms whole mountains; as, for example, the

calcareous ground. Mr. Ferber, in his 16th letter from Italy, describes 20 varieties of Porfido, under four species. But in general it is considered according to the colour of its ground, viz. either *red, purple, grey, green, or black*. When the ground is of jasper (Sect. 107. and following), the porfido is very hard. The *red* commonly contains *felt-spar*, in small white dots or specks, and often together with these, black spots of shoerl. The *green* is either a jasper or shoerl, with spots of quartz. This is often magnetic. Sometimes a porphyry of one colour contains a fragment of a porphyry of another colour. Those that have *chert* for their ground, are fusible *per se*. The Calcareous Porphyry consists of *quartz, felt-spar, and mica*, in separate grains, united by a calcareous cement. And finally, the Micaceous Porphyry, consists of a greenish-grey micaceous ground, in which red felt-spar and greenish soap-rock are inserted. *The Editor.*

[d] This stone is so called, on account of its most common external appearance or figure; it being formed into steps like a stair, called *trapp* in Swedish. Bergman found that this stone has the same component parts as the *basaltes*; and there cannot be the least doubt of both being the very same substance.

It is generally called *Saxum Danemorense*. According to Kirwan, it is composed of *Siliceous earth*, mixed with 0,3 of its weight of *argill*, 0,17 of *mild calcareous earth*, 0,04 of *magnesia*, and 0,5 of *iron*. Bergman, however, had expressed the same contents of this stone in an easier way, at p. 213 of his *Treatise de Productis Vulcanicis* of Upsal's edition, 1783; saying that the *trapp* has the very component parts, and in the same proportion, as the *basaltes*, viz. in 100 parts, 52 are of *siliceous earth*; 15 of *argillaceous*; 8 of

aerated

the mountain called Hunneberg, in the province of Westergottland, and at Drammen in Norway. But it is oftener found in the form of veins in mountains of another kind, running commonly in a serpentine manner, contrary or across to the direction of the rock itself. It is not homogeneous, as may be plainly seen at those places where it is not pressed close together; but when it is pressed close, it seems to be perfectly free from heterogeneous substances.

When this kind is very coarse, it is interspersed with felspar; but it is not known if the finer sorts likewise contain any of it. Besides this, there are also some fibrous particles in it, and something that resembles a calcareous spar. This however does not ferment with acids; but melts as easily as the stone itself, which becomes a black solid glass in the fire. By calcination it becomes red, and yields in assays 12 or more per cent. of iron. No other sort of ore is to be found in it, unless now and then somewhat merely superficial lies in its fissures; for this stone is commonly, even to a great depth in the rock, cracked in acute angles, or in form of large rhomboidal dice.

It

agitated calcareous; and 25 of *iron*, if analysed by the *phlogisticated* alkali; if otherwise, by the common method, only 10 parts of the iron could be determined.

But although this great man found the same component parts, and the very similar appearances, both in the basaltes and the trap, he did not admit the last to be a volcanic production. I leave to the reader to decide upon the arguments on which this great man has grounded his doubts: yet since small pieces of lavas, and other volcanic productions, are really

It is employed at the glass-houses, and added to the composition of which bottles are made. By the Germans it is called *Schwach* or *Schwartstein*; at the Swedish glass-works, *Trappskiol*, *Tegelskoil*, or *Swartskoil*; and at Jarlsberg in Norway, *Blabest*. In the air it decays a little, leaving a powder of a brown colour; it cracks commonly in the fire, and becomes reddish brown if made red hot. It is found

1. Of coarse chaffy particles, *Particulis majoribus acerosis*.
 - a. Dark grey, from the top of Kinnekulle in the province of Westergottland.
 - b. Black, from Stallberget at Osterfilsilverberget in the province of Dalarne.
2. Coarse-grained, *Particulis majoribus granulatis*.
 - a. Dark grey, from the uppermost stratum at Hunneberg in Westergottland.
 - b. Reddish, from Bragnas in Norway.
 - c. Deep brown, from Gello in Norway.
3. Of fine imperceptible particles, *Particulis impalpabilibus*.
 - a. Black. The touchstone, *Lapis Lydius*, from Salberg mine, Hellefors Westerfilsilverberget,

found, where no appearance of fused matters can be discovered, they must be attributed to the great convulsions and revolutions of this globe, already hinted at in the note to p. 486; which have overthrown, and even transported to very distant places of the earth, where no other volcanic traces can be found, very large tracts and mountains of basalt, trapp, and lavas, after they have been formed by anterior eruptions of volcanic fires, &c.

berget, and Norberg in Westmanland, and Osterfilverget in Dalarne, &c. [b]

b. Blueish, from Osterfilverberget.

c. Grey, from Dalwik in the parish of Sorberke in Dalarne.

d. Reddish, from Dalstugun in the parish of Rettwik in Dalarne.

The texture of the trapp is either coarse, rough, and distinct, in its aggregate parts, or else they are fine and indiscernible. This last sort is often reddish, always opaque, and moulders by exposure to the air. Some of its specimens give fire with steel very difficultly, though it is always very compact. It looks sometimes as sprinkled over with a few minute shining particles.

Its specific gravity is $\approx 3,000$. It is generally invested with a ferrugineous crust; and is often crystallised in opaque triangular, or polyangular, columns. In this case it is called by the name of *Basalt*: but that which is amorphous, or breaks in large, thick, square pieces, is called by the general name of *Trapp*.

When heated red hot, and quenched in water, it becomes by degrees of a reddish brown colour.

It melts *per se*, in a strong heat, into a slag.

Borax dissolves it by fusion in the *dry way*; but mineral alkali does not entirely. *The Editor*.

[b] The black variety (3. a.) is sometimes found so compact and hard, as to take a polish like the black agate; it melts, however, in the fire to a black glass, and is, when calcined, attracted by the loadstone. Such a kind is found in the parish of Arla in the province of Sodermanland. *The Author*.

The touch-stone, or *Lapis Lydius*, has ever been, and is still now, one of the costly toys of silly *virtuosi*. Any black pebble, or a piece of black flint, does the same service as the very best *Lapis Lydius* of Asia. Even a piece of glass, made rough with emery, is successfully employed by our market dealers to distinguish gold pieces from counterfeits, both by the metallic colour, and by the test of *aqua fortis*. *The Editor*.

S E C T. 411. (268.)

H. Amygdaloides. *Saxum basi jaspidea martiale, cum fragmentis spati calcares et serpentini, figura elliptica* [a]. Mandelstein of some.

It is a martial jasper, in which elliptical kernels of calcareous spar and serpentine-stone are included.

a. Red, with kernels of white limestone, and of a green steatites. from Gello and Gullo in Norway, and the Hartz in Germany.

This is of a particular appearance, and when calcined is attracted by the loadstone; it decays pretty much in the air, and has some affinity with the Trapp (Sect. 410.) and also with the porphyry (Sect. 409.) There are sometimes found pieces of *native copper* in this stone at Gullo.

[a] These are the *carpolithi*, or fruit-stone rocks of the Germans, D. C. Bertrand asserts, that the *Amygdaloides*, or *Amygdalites*, are those stones which appear to be composed of such elliptical figures as petrified almonds, although in fact they are nothing else but small oblong pieces of calcareous stone, rounded by common attrition, and sometimes small muscle-shells, connected by a stony concretion. But the *carpolithi*, or fruit stone rock, is a general name given, by the fossil writers, to all sorts of stony concretions which represent any fruit whatever, of a larger, or smaller, size than almonds commonly are. See *Bertrand's Universal Dictionary of Fossils. The Editor.*

S E C T.

S E C T. 412. (269.)

I. The *Greonsten* of the Swedes. *Saxum compositum mica et hornblende.* Sect. 137.

Its basis is hornblende, interspersed with mica. It is of a dark green colour, and is dug in several places in Smoland, where it is employed in the iron furnaces, as a flux to the bog ore (Sect. 335.) It is also found in other places, as at Rettwik in Dalarne, and in the neighbourhood of some of the iron mines.

S E C T. 413. (270.)

K. The granites. *Saxum Compositum*] felspatomica and quartzo, quibus accidentaliter inter-dum hornblende, steatites, granatus et basaltus immixta sunt [a].

Its

[a] The granite is called also *Moor-stone* in England: it consists of distinct masses of various stones mentioned by the noble author, or the greatest part of them, firmly compacted together. Their proportion and size are extremely variable, as well as their colour. The quartz, felspar, and mica, constitute the hardest sort of granite, the most anciently known. That into which the *sharl* enters, is more subject to decomposition. The granite never has any particular texture or regular form, but consists of enormous shapeless masses, of great hardness.

Its principal constituent parts are *felt spar* or *rhombic-quartz*, *mica*, and *quartz*.

It is found.

1. Loose or friable, *Particulis confans parum coherentibus*.

This is used at the brass works to cast the brass in, and comes from France.

2. Hard and compact, *Granites durus*.

a. Red.

1. Fine-grained, from Swappawari at Tornea in Lapland.
2. Coarse-grained, from Bispbergs Klack, in the province of Dalarne,

b. Grey,

In the finer granites, the *quartz* is transparent; in others generally white or grey, violet or brown. The *felspar* *white*, *yellow*, *red*, *green*, or *black*, is generally the most copious ingredient. The *mica* is also *grey*, *brown*, *yellow*, *green*, *red*, *violet*, or *black*, and is commonly least copious. The *shoerl* is generally *black*, and abounds in the granites that contain it.

Hence the colour of granites chiefly depends on that of the *spar* or *shoerl*. The *red* granites consist commonly of *white quartz*, *red felspar*, and *grey mica*. The *grey* of *white quartz*, *grey* or *violet felspar*, and *black mica*. The *black* commonly contain *shoerl* instead of *felspar*: and the *green* commonly contain *green quartz*.

If granite be exposed to the flame, urged by a blow-pipe, its different concretions separate from each other. In a crucible, Mr. Gerhard found the *felspar* of a piece of granite melted into a transparent glass; under it the *mica* lay in the form of a black flagg. and the *quartz* remained unaltered. But when all three were powdered and mixed, it melted somewhat better; yet still the *quartz* may be distinguished by the help of a lens. This well explains why small white grains are frequently found in lavas. The experiments of Mess. d'Arcet and Saussure perfectly coincide on this subject.

The

b. Grey, with many and various colours, found on the coast round Stockholm and Norland.

The Granites are seldom flaty or laminated, when their texture is close, and the harder particles, as the felspat or rhombic quartz, the quartz, and the shirl, predominate in it. They admit of a good polish, for which reason the Egyptians in former times, and the Italians now, work them into large pieces of ornamental architecture, for which purpose they are extremely fit, as they do not decay in the air.

The mixture of mica prevents the flex or quartz from cracking or splitting; and hence its infusibility and advantageous use in furnaces.

The *granitone*, mentioned by Ferber in his letters from Italy, is a stone composed of *felspar* and *mica*. A substance of this kind, which moulders by being long exposed to the air, is found in Finland; it is said to contain sometimes *saltpetre*, and sometimes *common-salt*. It is there called *Rapakivi*. Wallerius describes 18 species of granites, besides many other granatic stones, on which the curious reader may consult his Mineralogic System of the edition in 1778. *The Editor, chiefly from Kirwan.*

SECT. 414. (271.)

2. Conglutinated Saxa, *Saxa conglutinata*.

A. Of larger or broken pieces of stones of the same kinds conglutinated together, *Saxum conglutinatum fragmentis lapidum. Breccia* [a].

I. Of

[a] The Stones called *Ludi Helmontii*, or *Paracelsi*, have some similarity, in their form, to the *breccia* of this Section; for they are composed of various lumps of a marly whitish-brown matter, separated into a great number of polygonous compartments, of various sizes, formed of a whitish-yellow crust of a red calcareous spar, sometimes pyritous, which often rise a little above the external surface, and inclose each of them on the inside. According to Bomare, the *Ludus Siselatus Helmontii*, found in the county of Kent, is covered with a kind of striated selenite, resembling the zeolite.

They are for the most part of a globose figure, seldom flat, but often convex on the outside. And sometimes with a concave surface.

According to Wallerius, the *Ludus Helmontii* loses by calcination about half of its weight; and, on being urged by fire, is melted into a black glassy slag. It effervesces strongly with *aqua fortis*, and this solution is of a yellow colour. But what seems very extraordinary, by adding to it some oil of tartar *per deliquium*, bubbles are produced, from which a great number of slender black threads, or filaments, are produced, sticking like a cobweb to the sides and bottom of the vessel.

These stones are found quite separate by themselves, as well as various *stalagmites* and *crustaceous boates*, on the strata of argillaceous earth, in various parts of Europe, chiefly in Lorrain, Italy, England (in the counties of Middlesex and Kent), and elsewhere.

Wallerius

1. Of limestone cemented by lime, *Saxum constans fragments lapidis calcarei, calce conglutinatis.*

a. The calcareous Breccia, *Breccia calcarea*; The *Marmi Brecciati* of the Italians.

When these kinds have fine colours, they are polished and employed for ornaments in architecture, and other æconomical uses; they come from Italy.

b. The *Lumacella* of the Italians, or shell marbles. These are a compound of shells and corals, which are petrified or changed into lime, and conglutinated with a calcareous substance. When they have many colours, they are called marbles, and employed for the same purposes as the preceding, likewise from Italy, from Bergen in Norway, and Offerdal in the province of Jemteland. In the island of Gottland there is found one of this kind of one colour only, which on that account is not called marble, or used as such. At Balsberget in the province of Skone, is found of a white lumacella, of weak colours.

Wallerius ranges the *Ludus Helmontii* among the *tophi*, in the *Spec.* 425, of his System of Mineralogy. Paracelsus had attributed to these stones a *Lithontriptic* power, and Dr. Grew says, that they are *diuretic*; but there is not the least proof of their really possessing such qualities. *The Editor.*

S E C T. 415. (272.)

2. Of kernels of jasper cemented by a jaspery substance, *Saxum fragmentis jaspidis materiâ jaspideâ conglutinatum*. *Breccia Jaspidea*. *Diaspro brecciato* of the Italians.

Of this kind specimens from Italy are seen in collections. A coarse Jasper Breccia is said to be found not far from Frejus in Provence in France.

S E C T. 416. (273.)

3. Of siliceous pebbles, cemented by a jaspery substance, or something like it, *Saxum silicibus amorphis materiâ jaspideâ conglutinatis*. The plum-pudding stone of the English. *Breccia Silicea*.

Its basis, which is likewise the cement, is yellow, wherein are contained single flinty or agaty pebbles, of a grey colour or variegated. This has a very elegant appearance when cut and polished. It is found in England.

S E C T.

S E C T. 417. (274.)

4. Of quartzose kernels combined with an unknown cement, *Saxum fragmentis quartzosis conglutinatis. Breccia quartzosa*. Found in the provinces of Jemteland and Smoland,

S E C T. 418. (275.)

5. Of kernels of several different kinds of stones, *Saxum fragmentis variorum saxorum conglutinatis. Breccia saxosa*.
 a. Of kernels of porphyry, cemented by porphyry or a coarse jaspery substance, *Breccia porphyrea*, from Serna Fiell, and Hykieberget in the province of Dalarne.
 b. Of kernels of several saxa, *Saxum fragmentis variorum saxorum compositorum conglutinatis. Breccia indeterminata [a]*.

[a] The above mentioned Breccia require the distinctions here made between them, but which perhaps may seem to be carried too far, since their particles are so large and perfect as to be easily known from one another. These stones are a proof both of those subversions which the mountains in many centuries have undergone, and of some hidden means which nature makes use of in thus cementing different kinds of stones together. Any certain bigness for the kernels or lumps in such compounds, before they deserve the name of Breccia, cannot be determined, because that depends on a comparison which every one is at liberty to imagine. At one place in the mountain called Hykieberget, the kernels of porphyry have a diameter of six feet, while in other places they are not bigger than walnuts. At Mafsewala the kernels have a progressive size down to that of a fine sandstone. Most of this kind of stone is fit for ornaments, though the workmanship is very difficult and expensive. *The Author.*

Is found in loose stones in Dalarne, originally broken from the Fiell tracts in Serna, which consist of nothing else but conglutinated stones.

c. Of conglutinated kernels of sandstone, *Saxum fragmentis constans saxorum conglutinatorum. Breccia arenacea.*

This kind consists of sandstones (Sect. 419.) kernels, which have been combined a second time together. This is also found in loose stones in Dalarne, and are perhaps originally broken from the above-mentioned Fiell in Serna,

S E C T. 419. (276.)

B. Conglutinated stones of granules or sands of different kinds, *Saxum conglutinatum granulis seu arenâ variorum lapidum.* Sandstone, *Lapis arenaceus* [*a*].

In this division are reckoned those which consist of such minute particles, that all of them

[*a*] Sandstones are of great use as materials for buildings which resist fire, air, and water. Some of them are soft while in the quarry, but harden in the open air. The loose sandstones are the most useful: but the solid and hard ones, such as *c.* and *d.* crack in the fire, and take a polish when used in grindstones. however, though the Burfwik's stone (*i. b.*) is pretty loose

them cannot easily be discovered by the naked eye. The greatest part, however, consist of quartz and mica, which substances are the most capable of being granulated without being brought to a powder.

I think I have reason to consider this kind in regard to the substance which has served as a cement to combine them, although it is not always perfectly discernible.

1. Cemented by clay, *Lapis arenaceus glutine argillaceo*.

a. With an apyrus or refractory clay, *Argilla porcellanæ*.

It is found under the stratum of coal in the coal-mine at Boserup in Skone; is of a loose texture, but hardens, and is very refractory in the fire.

b. With common clay, *Argilla communi*, from Burfwick in the island of Gottland.

2. With lime, *Lapis arenaceus glutine calcareo*; resembles mortar made with coarse sand.

a. Consisting of transparent and greenish grains of quartz and white limestone; from the island Ifo, near Beckaskog in Skone.

b. Of

in its texture, it is nevertheless unfit for buildings which are exposed to fire or open air, because it breaks to pieces and melts in the fire, and in the air it attracts the moisture, decays in process of time, and cracks in the cold, which proceeds from the included kernels of clay expanding themselves when they grow wet. Sand-stones ought therefore to be very nicely examined before they are employed for the usual purposes.

These

- b.* Of no visible particles, from France and Livonia. This is of a loose texture, and hardens in the air.
3. With an unknown cement, *Lapis arenaceus glutine incognito, forsan argillaceo.*
- a.* Loose, from Helsingberg in Skone.
- b.* Harder, from Roslagen, Orsa, and Kinnekulle.
- c.* Compact, from Gefle in the province Gestrikeland, and the lake Malaren.
- d.* Very hard, from Serna Fiell or Fells in Dalarne; it is also found in great abundance in loose stones at Gustavsstrom, and at Siliamfors in the parish of Mora in Dalarne.
4. Cemented by rust or ochre of iron, *Lapis arenaceus ochra martis conglutinatus.* Is found in form of loose stones at several places, and ought perhaps to be reckoned among the *Minera Arenacea* or Sand-Ores of Sect. 420; at least when the martial ochre makes any considerable portion of the whole.

S E C T.

There are many quarries of sandstones in Sweden, but no enquiry has been made if any of them, and which can be employed in the larger works, instead of the English, and in the smaller manufacturies, instead of the Bohemian sandstones. Such enquiries are of greater consequence, in proportion as those manufactures increase wherein they are wanted.

It must be remarked, that the working masons, or stone-cutters, ought to wear a piece of frieze or baize before their mouth and nose, in order to preserve themselves from a premature death, which is unhappily at present the case with them in the parish of Orsa in Dalarne, and in other places.

But

S E C T. 420. (277.)

C. Stones and ores cemented together, *Saxum fragmentis constans lapidum et minerarum conglutinatis. Mineræ Arenaceæ.*

1. Of larger fragments, *Fragmentis lapidum et minerarum majoribus.*

a. Mountain green, or *Viride Montanum Cupri*, and pebbles cemented together, from Siberia.

b. Potters lead ore, with limestone, slate-kernels and shells from Gragrufvan at Boda in Rettwik, and in Dalarne.

c. Yellow or marcasitical copper ore, with small pebbles,

But limestone is not found to have this bad effect. *The Author.*

To the above we may add *Grit-stone* of greater or less hardness, mostly of a grey, and sometimes of a yellowish colour; composed of a siliceous and micaceous sand, and rarely of a sparry kind, with greater or lesser particles closely compacted and united by an argillaceous cement. It gives some sparks with steel, is indissoluble for the most part in acids; and vitrifiable in a strong fire. It is used for mill-stones, and whet-stones; sometimes for filtering-stones and for building. *Fabroni.*

N. B. The Argillaceous *grit* has been described in Sect. 150, p. 260.

S E C T.

S E C T. 421. (278.)

2. Of smaller pieces, *Granulis lapidum et minerarum* [a].
 - a. Potters lead ore with a quartzose sand, from Eiffelsfeldt near Cologn in Germany.
 - b. Mountain green with sand, from Siberia.
 - c. Cobalt ore with sand.
 - d. Martial ochre with sand.

[a] The *Mineræ Arenaceæ* or Sand-ores, cannot reasonably be separated from the sand-stones, since they are produced in the same manner; besides, when they are poor in yield, they are also employed to the same purpose, because it is not easy to smelt the metal out of them. The sand-ores, besides, cannot be ranked in a Mineral System as separate species of ores, because they would then be arranged with respect to the kind of stone in which the ore occurs, and not the ore itself, which case cannot be admitted here. It might be urged, that ores, mixed with the stones of the very load, and not in form of sand ores, ought as well as them to be ranked among the compound saxa: but in that case there would be no end of species, nor could they ever be reduced into any order. *The Author.*

S E C T.

S E C T. 422. (279.)

OBSERVATIONS on the SAXA or STONES.

Besides the advantages which may accrue to economy by a perfect knowledge of the Saxa, the miners or subterranean geographers expect also another future benefit from it, viz. that of concluding, from many observations, whether all the Saxa are to be equally attended to; for example, whether in some of them veins or strata of ores may be expected, and whether those are only of certain kinds; whether others are every where found destitute of any ore whatsoever; which of them are observed to form coats on the surface of the rock, that cover other kind of stones, or veins and strata of ores, &c. If no general rules can be deduced from such observations, there is a probability, at least, of gaining some knowledge that may be peculiar to certain countries; and this opinion is already in some places confirmed by experience. Hence it may be concluded, how necessary it is to communicate all such observations which, for the above-mentioned purposes, ought to be made over the whole globe, and also to agree on fixing certain names on the *Saxa*, in order to avoid too great a prolixity in their descriptions. It is

M m m

with

with this intention I have here, as a specimen, given specific names to those Saxa which are found in this northern country, and are known to me, wishing at the same time to be acquainted with a method to distinguish them more easily and to better purpose.

This procedure will be found still more necessary and useful, as the world seems resolved soon to abolish the superstition of the Hazel Rod or *Virgula Divinatoria*, and that we have by means of observations already gained too much experience to believe, that the strata of earths and stones are placed equally and in the same order and situation over the whole earth; which some, however, in these our times have even endeavoured to prove, while others have made a secret of it, in hopes of enriching themselves.

S E C T. 423. (280.)

The SECOND ORDER.

MINERAL-CHANGES, or the PETRIFICATIONS.

Mineralia-Larvata, vulgo *Petrefacta* [a].

Are mineral bodies in the form of animals or vegetables, and for this reason no others belong
to

[a] The Noble Author has very judiciously confined to the 13 following small Sections, all that is worthy of being known by mineralogists about petrifications, a subject upon which

to this order, than such, as have been really changed from the subjects of the other two kingdoms of nature.

There is more difficulty to determine the first point, viz. from when these bodies are to be styled petrefactions, than from when they cease to be such; meanwhile I have, in order to make a trial, considered them in the following manner.

S E C T.

which many voluminous works have been given to the public, with immense labour and erudition, tho' both were very idly employed. The celebrated Wallerius, not to mention his numberless predecessors of the same stamp, has had the patience, to employ no less than 270 pages of his Mineralogy, with an account of the *concrete*, *figured*, and *petrified fossils*, above half (189 pages) of which he has intirely devoted to the last kind of bodies. But what is very remarkable, and must excite the smiles of a sober reader, is the pompous Greek nomenclature that has been bestowed upon such trifling and childish objects: *phytotypolithes*, *meandrites*, *entomolithes*, *apomosoftomes*, *orboceratites*, &c. are to express *petrified plants*, coralloides, crabs, echinites, and shells of sea-insects. I shall forbear to make any additional notes about these matters. But the curious may easily apply for information to the *Oryctology*, or *Dictionary of Fossils*, published in French by E. Bertrand at the Hague, in 1763, in 2 vols in 8vo.; and to some other authors on the subject. *The Editor*.

The most remarkable observations, relative to petrifications, are,

1. That those of *shells*, are found on or near the surface of the earth; those of *fish* deeper, and those of *wood*, deeper still. Shells in *specie* are found in immense quantities at considerable depths.

2. That those organic substances that resist putrefaction most, are frequently found petrified, such as *shells*, and the harder species of *woods*. On the contrary, those that are aptest to putrify, are rarely found petrified, as *fish*, and the softer parts of *animals*, &c.

M m m 2.

3. That

S E C T. 424. (281.)

1. Earthy Changes, *Terræ Larvatae*. *Terri-
ficata*.

A. Extraneous bodies changed into a lime substance, or calcareous changes, *Larvæ calcareae*.

1. Loose or friable, Chalky changes, *Cretæ larvatae*.

a. In form of vegetables.

b. In form of animals.

1. Calcined or mouldered shells, *Humus con-
chaceus*, from the province of Helsingeland,
at Uddevalla in the province of Halland,
and in the French strata of earth and
chalk.2. Indurated, *Petrefacta calcarea*.

a. Changed and filled with solid lime-
stone.

1. In form of animals.

2. In form of vegetables.

3. That they are most commonly found in strata of marl, chalk, lime-stone, or clay : seldom in sand-stone ; still more rarely in gypsum ; but never in gneiss, granite, basalt, or shoerl. But they sometimes occur among pyrites, and ores of iron, copper, and silver ; and almost always consist of that species of earth, stone, or other mineral, that surrounds them ; sometimes of flint, agate, or cornelian.

4. That they are found in climates, where their originals could not have existed.

5. That those found in *slate*, or *clay*, are compressed and flattened. *The Editor from Kirwan.*

Found

Found in the island of Gottland.

b. Changed into a calcareous spar, *Petre-
facta calcarea spatosa.*

1. In form of animals.

The shells in Balsberget in the province of Skone.

2. In form of vegetables [*b*].

S E C T. 425. (282.)

B. Extraneous bodies changed into a flinty substance. Siliceous changes, *Larvæ.*
These are like the flint,

[*b*] Shells and corals are indeed composed of limy matter, even when their animals still dwell in them; nevertheless, although they are not changed in regard to their principle, yet they are reckoned among the petrefactions, as soon as the particles of the calcareous substances have obtained a new situation; for example, when they are become sparry, when they have been filled with a calcareous earth, either hardened or loose, or when they lie in the strata of the earth. These form the greatest part of fossil collections, which are so industriously made, often without any regard to the only and principal use they can be of, viz. that of enriching zoology. Mineralogists are satisfied with seeing the possibility of the changes the limestone undergoes in regard to its particles, and also with receiving some insight into the alteration which the earth has been subject to, from the strata which are now found in it.

The calcined shells, or those which have been changed into limy and chalky matter, are fit to make lime, and are still more serviceable as a manure. The indurated serve only to make grottos. No gypseous petrefactions are known, if such are not found in the Persian alabaster; for Mr. Charadin says, that he has seen a lizard included in that stone.

The Author.

M m m 3 r. Indurated,

1. Indurated, *Petrefacta filicea*.
 - a. Changed into flints.
1. Carnelians in form of shells, from the river Tomm in Siberia.
2. Agat in form of wood, Such a piece is said to be in the collection of Count Tessin.
3. Coralloids of white flint, (*Millepora*) found in Gottland.
4. Wood of yellow flint, Italy, Adrianople, and Loughneagh, a lake in Ireland,

S E C T. 426. (283.)

C. Extaneous bodies changed into clay. Argillaceous changes, *Larvæ argillacea*.

a. Loose and friable.

1. Of porcellane clay.

a. In form of vegetables.

A piece of white porcellane clay from Japan, with all the marks of the root of a tree, has been observed in a certain collection.

b. Indurated.

1. In an unknown clay. See page 77. a.

a. In form of vegetables. *Osteocolla*. It is said to be changed roots of the poplar tree, and not to consist of any calcareous substance. See the *Physicalische Belustigugen*.

A sort of fossil ivory is said to be found, which has the properties of a clay; but I do not know if it is rightly examined.

S E C T.

S E C T. 427. (284.)

2. Saline extraneous bodies, or such as are penetrated by mineral salts, *Corpora peregrina insalita. Larvæ insalitæ.*

A. With the vitriol of iron, *Vitriolo martis insalita.*

1. Animals.

a. Human bodies have been twice found in the mine at Falun in Dalarne; the last was kept a good many years in a glass case, but began at last to moulder and fall to pieces.

2. Vegetables.

a. Turf, and

b. Roots of trees.

These are found in water strongly impregnated with vitriol; for instance, in the moor at Osterfilsberget in Dalarne. They do not burn with a flame, but only like a coal in a strong fire; neither do they decay in the air.

S E C T. 428. (285.)

Extraneous bodies penetrated by mineral inflammable substances, or mineral phlogiston, *Corpora peregrina phlogistis mineralibus impregnata.*

M m m 4 *A.* Penetrated

A. Penetrated by the substance of pit-coal, *Lithantrace impregnata*.

1. Vegetables, which commonly have been woods, or appertaining to them.

a. Fully saturated. *Gagas. Jet.* See Sect. 240. p. 473.

The jet is of a solid shining texture. From England, Boserup in Skone, and the Black Sea.

b. Not perfectly saturated. *Mumia vegetabilis*. Is loose, resembles umbre, and may be used as such. From Boserup.

S E C T. 429. (286.)

B. Penetrated by rock oil or asphaltum, *Corpora peregrina petroleo seu asphalto impregnata*.

1. Vegetables.

a. Turf in the province of Skone.

The Egyptian mummies cannot have any place here, since art alone is the occasion that those human bodies have in length of time been penetrated by the asphaltum, in the same manner as has happened naturally to the wood in pit-coal strata (Sect. 428.)

S E C T. 430. (287.)

C. Penetrated by sulphur which has dissolved iron, or by marcasite and pyrites, *Pyrite impregnata. Petrefacta pyritacea*.

1. Human.

1. Human.

a. Bivalves,

b. Univalves, and

c. Insects.

In the alum slate at Andrarum in Skone.

S E C T. 431. (288.)

4. Metals in the form of extraneous bodies,
Larvæ metalliferæ.

A. Silver, *Larvæ argentiferæ.*

1. Native.

a. On the surfaces of shells. England.

2. Mineralised with copper and sulphur.

a. Fahlertz or grey silver ore (Sect. 272. and 276.) in form of ears of corn, &c. and supposed to be vegetables, are found in argillaceous slate at Frankenberg and Tahliterten in Hesse.

S E C T. 432. (289.)

B. Copper, *Larvæ cupriferæ.*

1. Copper in form of calx, *Cuprum californice corpora peregrina ingressum.*

a. In form of animals, or of parts belonging to them.

1, Ivory, and other bones of the elephant.
The Turquois or Turkey stone: It is of a blueish

blueish green colour, and much valued in the East. See Sect. 323. p. 686.

At Simore in Languedoc bones of animals are dug, which during the calcination assume a blue colour; but it is not probable that the blue colour is owing to copper.

S E C T. 433. (290.)

2. Mineralised copper, which impregnates extraneous bodies, *Cuprum mineralisatum corpora peregrina ingressum*.

A. With sulphur and iron. The yellow or marcasitical ore that impregnates

1. Animals.

a. Shells, from Hagatienns Schurff and Jarlsberg in Norway. These shells lye upon a loadstone,

b. In form of fish, from Eisleben, Mansfeld, and Osterode, in Germany.

B. With sulphur and silver. Grey silver ore at Fahlertz, like ears of corn, from the slate quarries in Hesse (Sect. 431.)

S E C T. 434. (291.)

C. Changes into iron, *Larvæ ferriferæ*.

1. Iron in form of calx, which has assumed the place or the shape of extraneous bodies,

Ferrum calciforme corpora peregrina ingressum.

a. Loose,

- a. Loose, *Larvæ ochraceæ*.
- 1. Of vegetables.
Roots of trees, from the lake Langelma in Finland: See the Acts of the Swedish Academy of Sciences for the year 1742.
- b. Indurated, *Larvæ hæmatitica*.
1. Of vegetables.
Wood, from Orbissau in Bohemia.

S E C T. 435. (292.)

- 1. Iron mineralised, assuming the shape of extraneous bodies, *Ferrum mineralisatum corpora peregrina ingressum*.
a. Mineralised with sulphur. Marcasite.
Larvæ Pyritaceæ. Sect. 430.

S E C T. 436. (293.)

- 4. Extraneous bodies decomposing, or in a way of destruction, *Corpora peregrina in gradibus destructionis considerata*. Mould, *Humus*. Turf, *Turba*.
A. From animals. Animal mould, *Humus animalis*.
1. Shells. *Humus conchaceus*.
2. Mould of other animals, *Humus diversorum animalium*.
B. Vegetable mould, *Humus vegetabilis* [c].
1. Turf,

[c] All the kinds of mould contain some of the inflammable substance, which has remained in them from the vegetables or animals, and they are more or less black, in proportion

1. Turf, *Turba*.

a. Solid, and hardening in the air, *Turba solida aëre indurescens*. Is the best of this kind to be used for fuel, and comes nearest to the pit-coals. It often contains a little of the vitriolic acid.

b. Lamellated turf, *Turba foliata*. This is in the first degree of the destruction.

2. Mould of lakes, *Humus lacustris*. This is a black mould, which is edulcorated by water.3. Black mould, *Humus ater*.

This is universally known, and covers the surfaces of that loose earth in which vegetables thrive best.

S E C T.

as they contain more or less of this phlogiston. I have ranked them in this place, that they might not be totally excluded. They are else a *medium uniens* between all the three kingdoms of nature: and it may reasonably be asked, if all sorts of earth do not in form of very minute particles enter into the composition of vegetables and animals, after which they exist for some time in form of mould, until the phlogiston is again separated. *The Author*.

The black mould yields by distillation an oily and alkaline substance. *Humus atra* (says Wallerius) *destillatione dat phlegma, plus minus pro ratione siccitatis*, 2. *Spiritum acrem foetidum, qui quo obscuriori distillat colore, eo magis acris & empyreumaticus, non tamen salinus, utpote nec cum acidis nec cum alkalinis effervescebat, sed oleosus spiritui tartari odore et sapore similis*: 3. *Et denique quidpiam oleosi rubentis*.—*In English*. The black mould affords, when distilled, more or less phlegm, according to the degree of its dryness: 1dly, a sharp fetid liquor, which is more acid and empyreumatic in proportion as it is of a darker colour: but it neither effervesces with acids nor alkalis; has an oleaginous appearance, and resembles, both in taste and smell, the spirit of tar

S E C T. 437. (294.)

The THIRD ORDER.

NATURAL SLAGS,

Scoria Vulcanorum [d].

Slags are found in great abundance in many places in the world, not only where volcanos yet

tar and lastly, a small quantity of a reddish oil. *The Editor.*

[d] 1. Volcanos, or burning mountains, are peculiar to no climate, and have been observed in every quarter of the globe, as Kirwan observes. They have no necessary or regular connection with those of other mountains; it seems, however, that the contrary is sometimes the case, as mount *Ætna*, or *Gibello*, in the island of Sicily, has been observed to have made some extraordinary explosions, when *Vesuvius* in Italy was in its greatest convulsions.

2. These burning mountains are of various sizes, that of *Tana* in the Pacific Ocean is no higher than 450 feet; but others of the kind are considerably high. *Ætna* in the island of Sicily is above 24 times higher, viz. 10,954 feet, according to what is said in the *Phil. Trans.* vol. 67. p. 595. These mountains generally form lofty spires internally shaped like an inverted cone, placed on a broad basis, which is upwards; this is called the *Crater* of the Volcano, and through it the lava and other ejected matters generally pass; though it sometimes bursts from the sides, and even from the bottom of the mountain. Sometimes, also the crater falls in, and is effaced. In extinguished volcanos it is often filled with water, and forms those lakes that are observed on the summits of various mountains.

yet exist, but likewise where no subterraneous fire is now known. Yet, according to our opinions, they cannot be produced but by means of

3. Both the crater, and basis of many volcanos, consist of lavas, either solid and intire, or decomposed, nearly as low as the level of the sea: but they finally rest upon *granite*, as the volcanos of *Peru*; or on *Schistus*, as the extinguished volcanos of *Hesse* and *Bohemia*; or, finally, on *lime-stone*, as those of *Silesia*, the *Vicentine Alps*, and mount *Vesuvius* in Italy. The decomposed and undecomposed lavas form irregular strata, that are never parallel to each other; and, besides *iron*, of which they contain from 20 to 25 *per cent.* *sulphur*, and some fragments of *copper*, *antimony*, and *arsenic*, they contain no other ores.

4. The immense quantities of matter thrown up, at different periods, by volcanos, without lessening the apparent bulk of their mountains, shew that the seat of these fires must be several miles, perhaps hundreds of miles, below the surface of the sea; and in fact there are records of various volcanic explosions under the bottom of the sea, one of which happened a few years ago near Iceland. And, as *iron* makes from $\frac{1}{3}$ to $\frac{2}{3}$ of all these ejections, we may infer, that the interior parts of the earth consist chiefly of this metal, its ores, and those stones that contain it, whose greater or lesser dephlogistication in different parts may cause the variation of the magnetic direction in various places of the globe.

5. It is well known that martial pyrites, being moistened, acquire heat, and if there be the concurrence of pure air, it will burst into actual flame; but when there is no such communication, we may suppose that the heated pyrites may be in contact with *black wad* (pag. 859), and *petrol* (Sect. 236. and that the flame may be fed by the *vital* or *dephlogisticated air* that is produced from those substances which are known to afford it, in the same manner as nitre is employed to entertain the flame in the modern manufactories of *vitriolic acid*.

6. As to the explosion or eruption of the melted and scorified matters thrown out by the volcanic mouths, it may naturally arise from large quantities of water, which enter by some cracks,

of fire. These are not properly to be called natural, since they have marks of violence, and of the last change that mineral bodies can suffer

cracks, and hollow communications, formed by the weathering of the interior veins of soft substances between the mountains and the sea, rivers, or sources of water, in the neighbourhood of them; or else the water may be naturally produced within those enormous cavities on the inside of the volcanic mountains; since it has been lately discovered (or at least asserted) by some naturalists, that this fluid substance may be formed by the intimate union and deflagration of *inflammable* and *dephlogisticated* air.

7. If the mass of the water be sufficiently great, it will extinguish the fire that had been lighted. On the contrary, if the water be in a less proportion, it will suddenly be converted into vapour, whose elastic force is known to be several thousand times greater than that of gun-powder. If the superincumbent weight be too great, it may cause earthquakes; but it will propel both the melted and diluted matters laterally towards the mouth of the volcano, where, meeting with the least resistance, it will expel them, together with all the unmelted stony masses it meets with in its passage.

8. It is easily conceived, that before the dense, soaked, and fused matters be ejected, the expanded air of the volcano will first be forced out, and carry with it the ashes and looser stones adhering to its sides and crater, as have been observed by eye witnesses, and various historians, to great distances. In the explosion of Vesuvius, on March 31, 1767, there were large blocks of stone, above 20 tons or 40,000 pounds weight, blown above 200 feet high according to Hamilton, and 1200 feet according to de la Torre. Bergman speaks of a rocky block of about 1000 cubic feet thrown to the distance of half a Swedish mile. The ashes of the eruptions, in 1631, went so far as *Ragusa*, *Sardinia*, and even to *Constantinople*, as Braccini asserts, quoted by B. Dietrich, in his notes to *Ferber's Letters*, where an account of the prodigious quantity and varieties of these volcanic ejections may be seen.

suffer without the destruction of the world; nor are they artificial according to the universally received meaning of this word. When
we

9. But the basaltcs, among these volcanic products, deserves to be mentioned in a more particular manner. Our author thought that they belonged to a very different kind, and confounded them with the shoerls, as appears by his 72d and following sections, at p. 207, and following, of his edition, where he called the Shoerl, or *Lapis Corneus* of *Wallerius's* first edition, by the name of *Basaltcs*. Bergman, in the Sect. 120 of his *Sciagraphia*, pointed out this impropriety, which has been corrected in the present edition.

10. Pliny, in his 36 book, chap. 7, asserts, that the *basaltic stone* had been discovered by the Egyptians in Ethiopia; 2dly, that the name of *Basaites* had been given to it; and 3dly, that it possessed both the colour and hardness of iron.

11. Bergman, Guetard, Kirwan, and other philosophers, seem to have decided, upon very plausible reasons, which the first named philosopher has judiciously exposed in his *Treatise de Productis Vulcanicis*, that the basaltcs have been formed in the *humid way*, from the fluid matters formerly ejected by volcanos: but Desmarest, Ferber, Baron de Dietrich, de St. Fond, and other learned men, are of opinion, that the formation of these wonderful masses were produced *via fida*, from the melted or fused matters ejected by the same volcanos. The basaltic substance is indeed far from the true vitreous state; and, when urged by fire, it runs into a black glass, whose texture has not the least resemblance to that of its crude state.

12. Basaltcs are found in two or three general forms; either amorphous in masses of all sizes and thickness. Sometimes lamellated like slate, and of large dimensions, and at other times very thick, forming solid blocks from the smallest size to that of the whole mountains. The trapp, already mentioned in Sect. 410, is of this kind.

13. The most remarkable basaltcs are those of a columnar form; they are properly *polyhedral* and polygonal, being composed of flat sides, which form a great variety of angles between themselves; but they cannot be called *crystallised*,

we perhaps in future times by new discovered means may be able to find out of what sort of earth stones are compounded, we shall still be forced

ised, because they never exhibit any regular figure or symmetrical disposition of parts, and of course they cannot be ranked among *crystals* or *crystallised* bodies. Some, though very rare, have a cylindrical form, like columns, so that the transverse section is a true circle, and even some have been found of a flattened shape, having an ellipsoide for their lateral section.

These polygonal columns consist of many sides, from 3 to 11, and sometimes more, seldom forming similar angles; and as to their size, they vary very much. Some are found, though very rarely, so small as to deserve the name of miniature, *viz.* from 4 to 5 *tenths* in breadth to one inch and a half in length; but the most common sized ones are from 5 to 11 and more inches in diameter, and from 1 to 16, 25, and 30 feet high.

14. Bergman asserts, that basaltic columns have been found of 30, 40, and more feet high, and of enormous thickness. Many of great dimensions are found, as Faujas mentions, near the castle of *Bastide*, and in the mountain of *Chenevari*, in the province of *Viverrais* in France, measuring, 3 $\frac{1}{2}$ feet in thickness, and 15 or 16 feet long. There are others still more voluminous in the *Expailly* of *Velai* in *Auvergne*, in the states of Venice, chiefly about *Vicenza* in *Sicily*, and in the province of *Antrim* in Ireland. One octagonal prism, from this last place, is kept in the *British Museum* of London, whose weight was guessed by Brunnich to be about 1300 pounds, and no doubt but much larger still may be found in the same and other places.

15. Solid bowls, or globes, and even of an oval form, have been found also, formed out of the basaltic substance. Some of an uniform mass, and others composed of concentric crusts, which may be separated by the blow of a hammer. A large and very singular one of this kind is represented in the last plate of the volcanic *Mineralogy* of Faujas de St. Fond printed in 1784. The natural process by which polygonous basaltes sometimes become of a spherical form, by losing their corners, was first observed by Messieurs the *Mor-*

forced to stop at the surface of them, and be contented with knowing that they contain a little

qu's de Laizier, Besson, and Delarbre, in the mountains of Auvergne in France. See the account given, by the last named gentleman, in Journal de Physique, for August 1787, p. 135.

16. Another sort of basaltcs shews a fibrous texture, like the Asbestus, though their colour and component parts are like those already described.

17. But the most numerous columnar basaltcs, in various countries, are of the articulated kind, each consisting of many smaller prisms of a short and similar form in their sides, disposed into the same number of angles, and under the same angular inclination to one another, terminated by two horizontal perpendicular bases, of which one is concave and the other convex, having a roundish prominence in the middle, which fits exactly on the hollow of the next prism. These polygonous prisms, or columns, stand upright, and sometimes variously inclined to the horizon; they stand very close to one another, leaving only some chinks between themselves, which seldom exceed the breadth of 4 or 5 tenths of an inch, and are filled for the most part with a calcareous spar, that often covers each prism like a natural varnish.

18. This circumstance demonstrates, that the volcanic lavas, which formed these basaltic prisms, were first in a soft state, and that either by simply cooling, or by the evaporation of some subtle mixture, they contracted their dimensions, forming themselves into all the varieties of polygonous prisms; such as we observe in various similar circumstances. That kind of Indian ware from China and Japan, whose outside surface is cracked into various small polygons, may serve as a sample in miniature of these phenomena: and I have seen a group of white artificial crystals, which assumed, by cooling in the oven, a basaltic form. This last has been already mentioned by Sir Wm. Hamilton in the 2d part of Phil. Trans. for 1786, p. 375.

19. The calcareous spar, just now mentioned, seem to demonstrate also, that when these volcanic fluid substances were settled, and had been already contracted in their dimensions, they

little iron. Mean while I cannot omit them here, since I have considered the petrefactions ;

they have then been overflowed by an inundation of dissolved calcareous earth, which covered their surfaces, and filled their chinks with those sparry incrustations. The same Sir Wm. Hamilton, to whose zeal we owe great elucidations on these subjects, affirms, that the lavas, which happened to run in their fluid state to the sea, from the *Etna*, and from the other volcanic mouths in the islands of *Lipari*, have assumed the form of prismatic basaltcs.

20. This regular and close correspondence of those pieces, that form the horizontal surface of the basaltcs among themselves, must lessen the surprize of those who travel in Italy, when they behold the many and extensive parts of the *Via Appia*, and of other antient pavements still remaining, through many miles, in various roads, in the neighbourhood of Rome, and other parts, formerly inhabited by the Romans. These old pavements are composed of large brown or blackish angular stones, so well adapted to each other, that it should require an immense labour to be framed by art ; but the Romans undoubtedly got them in this form from some basaltic quarries, such as have been lately discovered in various parts of Italy. Nevertheless, the labour and expence, of extracting, carrying, and fitting them to their public roads, must have been extremely toilsome. The greatest part of those large tracts of similar volcanic productions, not only in the Irish county of Antrim, but those of Vivarais and Auvergne in France, in Italy, and in Germany, as well as in various other provinces of Europe, afford certainly the same conveniency for paving modern roads ; but in all probability they never will vie, at least by their durability, for so many centuries to come, with the Roman ones. The ancient undertakings, even after so many ages, still appear to have been made on a gigantic scale, whilst the most magnificent attempts of our times only seem to be like the work of a race of puny pigmies, in comparison to the antient monuments.

Basaltcs are of various colours ; for the most part brown, or black, of different shades, some of as deep a *black* as the best ebony ; some are *blueish*, *greenish*, *grey*, and of an *ochreous yellow*, or *reddish* colour ; some are variegated with

tions; and therefore I will enumerate some of them, according to their external marks.

small spots of whitish shoerls, and of different colours; and some are *transparent* like glass, which last are employed with success in blackglass manufactories, for making bottles. To this last belong the *Lapis Obsidianus* of Pliny, the *Islandic Agate* of the next Section, and the *Lapis Gallinaceus* from Peru, in the Spanish America, which by its beautiful blackness assimilates to a large black bird of the crow kind in that country, called *Gallinazo*.

22. Mr. Latrobe told me that he had seen in Upper Lusatia, in the manor of *Bertholdsdorff* near *Herrnbut*, the chief settlements of the Moravian brethren, a rock of granite, which apparently bursts asunder by a vein of concentric basaltcs. This seems to have a communication with a conic hill of considerable height, called the *Hutberg*, which consists of basaltcs covered with mould, and has several parties of basaltic columns at the top: the country all around is covered with large blocks of granite.

23. There are also found basaltcs, with other various extraneous bodies, inclosed in their masses, which equally shew the fused state they had originally suffered; among these are crystallized *shoerls*, both white and black, calcareous *spars*, *zeolites*, *crystalites*, *saphyrs*, *garnets*, pieces of *porphyry*, *granite*, and of other stones. But the shoerls and white garnets that are found imbedded within the mass of basaltcs, they seem rather formed *via sicca*; as Ferber asserts, in his *eleventh letter*.

24. The mass which is formed into the basaltic shape, seems to be of the same very kind of the lava; but more elaborated, perhaps by a longer boiling, baking, or roasting, on the bowels or bottom of the volcanic crater. Bergman, who analysed various masses of basaltcs, found that at a *medium*, their component parts consist of 52 parts, or hundreds of *siliceous earth*; 15 of *argillaceous*; 8 of *mild calcareous earth*, and 25 of *iron*. And Faujas de Saint Fond gives the following proportions, *viz.* 46 of *siliceous*, 30 of *argillaceous*, 10 of *calcareous*; 6 of *magnesian earth*; and 8 of *iron*. The Editor.

S E C T.

S E C T. 438. (295.)

A. Iceland agat, Achates Islandicus niger.

It is black, solid, and of a glassy texture; but in thin pieces: it is greenish and semi-transparent like glass bottles, which contain much iron. The most remarkable is, that such large solid masses are found of it, that there is no possibility of producing the like in any glasshouse.

It is found in Iceland, and in the island of Ascension. The jewellers employ it as an agat, though it is too soft to resist to wear. See N^o 21 of the preceding note; and p. 473, and p. 923.

S E C T. 439. (296.)

B. Rhenish millstone, Lapis molaris Rhenanus.

Is blackish grey, porous, and perfectly resembles a sort of flag produced by Mount Vesuvius. If I am mistaken in this, I hope that somebody else will describe the constituent parts of this millstone.

S E C T. 440. (297.)

B. Pumice stone, Pumex [e].

It is

[e] The pumice stone, or *Bimstein* of the Germans, is rather a volcanic ejection, than a volcanic production. It is

It is very porous and blistered, in consequence of which it is specifically very light. It resembles that frothy slag which is produced in our iron furnaces.

1. White.

2. Black.

The colour of the first is perhaps faded or bleached, because the second kind comes in that state from the laboratory itself, viz, the volcanos,

S E C T. 441. (298.)

D. Pearl slag, Scoriæ constantes globulis vitreis conglomeratis.

of a *white, reddish-brown, grey, or black* colour. Its consistence is rough and porous, consisting of slender fibres parallel to each other; is very light, and so that it swims on water, and difficultly gives fire with steel. It seems to have originally been an asbestos decomposed by the action of fire; but, on observing the appearance of that glassy-slag produced in the iron furnaces, which quite resembles the pumice-stone, and is produced from the calcareous fluxes to help the fusion of the ore, it may rather be attributed to that kind of froth which must be formed at the top of the fused matters in the volcanic craters. 100 parts, according to Bergman, contain from 6 to 15 of magnesia, with a small proportion of calcareous earth, and the most part of silica.

Mr. Dolomieu has lately discovered at *Stromboli* another sort of *pumice*, which seems to be a ferrugineous granite, altered by fire.

The pumice-stone is commonly employed to rub smooth and polish the surface of metals, wood, pasteboard, stone, and of other matters, as, by the harsh and brittle particles of its substance, it carries off the crust and inequalities of the surface that is wanting to be evened and smoothed. *The Editor.*

Is

Sect. 443. VOLCANIC PRODUCTS. 919

Is compounded of white and greenish glass particles, which seem to have been conglutinated while yet soft, or in fusion. It is found on the isle of Ascension.

S E C T. 442. (299.)

E. Slag-sand or ashes. *Scoriæ pulverulentæ, Cineres Vulcanorum.*

This is thrown forth of the volcanos, in form of larger or smaller grains. It may perhaps be the principle of the Terra Puzzolana (Sect. 342. *a.*), because such an earth is said at this time to cover the ruins of Herculaneum near Naples, which, history informs us, was destroyed by a volcano during an earthquake,

S E C T. 443. (300.)

OBSERVATIONS on the preceding **SLAGS** [*f*].

It seems as if we could not go any farther in the arrangement of bodies belonging to the

[*f*] The substances ejected by volcanos are, *phlogisticated, fixed, and inflammable air; water, ashes, pumice stones, stones that have undergone no fusion, and lavas.* The water proceeds partly from the condensed vapours, and partly from the combination mentioned at N° 6 of the last note [*d*], or at least from that which has caused the explosion, as already described in the same note.

the mineral kingdom, than to the black mould (Sect. 436.) and the flags, as being the extremes.

However, if these flags likewise decay, and in length of time become an earth, which possibly may happen; there is then a new substance beyond them, which however may return back and circulate again in some known form. It is obvious how the old heaps of flags from the iron furnaces decay, and at last produce vegetables, which cannot be ascribed to a black mould alone carried thither by the wind. The same may perhaps happen with the natural flags in the open air; but we do not know if it is so, nor what different forms this and every other earth, which circulates in animals and

If the ashes of the volcano are plentifully moistened with water, they produce that kind of *tufa* or *topbi*, *traas*, and *pori*, all which are nearly of the same kind. Great heaps of *tufa*, or *topbi*, are found in Italy, forming various hills, and covering large tracts of land, from whence it is cut and carried for making the walls, vaults, and upper ceilings of houses; it is a very soft kind of stone, extremely advantageous for these purposes, on account of its small weight, and of being easily cut into any form. The inhabitants of Umbria, and other parts of Italy, dig, with very little labour, various subterraneous, corridors, and large excavations under earth, where they keep wines, and many provisions quite free from the irregularities and excesses of temperature. See the notes to p. 735.

The lava, according to Kirwan, is the immediate produce of liquefaction, or vitrification, by the volcanic fires; and must be distinguished from their other productions of the same ejected at the same time, having been affected by the water, either in a liquid or fluid state.

All lavas are more or less magnetic; give fire with steel, are generally of a granular texture, and fusible *per se*. Most

and vegetables, further assumes. However, in such circumstances, as their particles become or are already very minute, and most part of the phlogiston becomes volatile, when acted upon by heat or fire, it seems probable, that, by a slow separation of the phlogiston, or a union by means of salts, this earth is more apt to become a clay, provided it is not by any previous revolution laid in such places as to change it into slate, pit-coal, &c.

If at any time it should happen that a volcano should burst out of a mountain, whose strata we knew before, we could at least imagine some reasons for this wonderful effect. However, the learned would nevertheless, perhaps, want some knowledge about the substances

of them are decomposable by long exposure to the air, sooner or later, according to the proportion of iron and calcareous earth they contain; and according as they were more or less perfectly melted. By the observations of Sir William Hamilton, the lava of *Vesuvius* forms one or two feet of mould in 1000 years. This bed being afterwards covered with fresh lava from another explosion; and this, after mouldering by those of still later eruptions, affords some ground for calculating the age of the volcano, at least within certain limits. Recupero, a canon of the cathedral of Catania in Sicily, says, that if it be allowed to judge by the number of the lavas found in Mount Etna, disposed in alternate strata with vegetable earth, there must have been the space of 14,000 years to be formed from the deepest to the upper one.

Lavas may be reduced to these 3 varieties, *viz.* *cellular*, *compact*, and *viscous*. The *cellular* underwent only the first and lowest degree of fusion, being just mollified and heated to expell the *first air* contained in the argillaceous particles. Hence they abound in small cavities arising from the

stances of the strata, and the manner of their formation; since in this circumstance water and other obstacles have hindered people too much from making the due observations thereon.

Meanwhile, the more we consider, on the one part, all the modification and alterations the earths undergo by means of fire and water, by the free or impeded access of the air, by the volatility and attraction of the acid salts, whereby are produced solution and hardening, composition and separation; and, on the other part, reflect on the shortness of a man's life, perhaps also dedicated to other business, on the difficulty of observing the subterraneous effects, and

the expansion of that air, after it had recovered its elastic state; on this account they are often so light, as to float for some time on water, and have been mistaken for pumice-stones. Their colour is black, grey, brown, or reddish brown; and their cavities are even filled with crystallizations: of this sort is the black cellular mill-stone of the *Rhine*, mentioned in Sect. 439.

These stones contain from 45 to 50 *per cent.* of *silica*; from 15 to 20 of *iron*; 4 or 5 of pure *calcareous earth*; and the remainder is *argill*.

The *compact lavas* have undergone a more perfect degree of fusion; yet they are not entirely destitute of cavities, which contain finer crystals, or pieces more perfectly vitrified; their colour is black or brown; their fracture is still obscure and not glassy, as the stones themselves are opaque. If not cracked, they give a clear sound when struck. Their constituent parts are the same as the preceding ones. The usual fluxes attack them with difficulty; and microcosmic salt has scarcely any power over them.

The *vitreous* lava has been more completely melted, and forms vitrifications of different colours, generally black or
 ash

Sect. 443. VOLCANIC PRODUCTS. 923

and on several things, which prevent the making discoveries, by which we might find out some easier means to attain true knowledge by judicious experiments; the more we shall find what is wanted to form mineral systems, and for this reason be apt to excuse the faults of those which have been hitherto published.

From those who of themselves are susceptible of these sentiments, I suffer with pleasure that judgement, which I am myself ready to pronounce upon this Essay:

Transcat cum cæteris.

ash-coloured, rarely blue or greenish. According to the analysis made by Bergman of this lava, it afforded 49 per cent. of *silica*, 35 of *argill*, 4 of pure *calcareous earth*, and 12 of *iron*. Another specimen from the Lipari islands, afforded 69 of *silica*, 22 of *argill*, and 9 of *iron*. These lavas melt very difficultly *per se*. The *black Agate of Iceland*, described in Sect. 438, called otherwise the *Lapis Obsidianus*, and *Piedra de Gallinaço*, mentioned in N^o 21 of note [d] to pag. 916. is of this kind of lava, and has the same component parts.

The harder sort of *pitch stone*, which gives fire with steel, belongs to this species. This stone is of a greyish, greenish, black, red, or brown colour; has a glassy appearance, of a semi-vitrified substances; and melts easily *per se*. It often contains heterogeneous substances. Its component parts are 65 per cent. of *silica*, 16 of *argill*, and 4 of *iron*; the 14 wanting parts were dissipated in the analysis made by Wieg-
leb, as Kirwan asserts.

The beds of lava are deepest and narrowest in the proximity of the crater; and broader and shallower as they are more distant, unless some valley intervenes; *pumice-stone* and *ashes* lie still more distant. From these observations, says Kirwan, extinguished volcanos are traced.

The Basaltic mountains, which are very common in Sweden, seem to owe their origin to sub-marine volcanos.

The Editor.

D E S C R I P T I O N

O F A

Mineralogical Pocket-Laboratory;

AND ESPECIALLY THE

USE OF THE BLOW-PIPE

I N

M I N E R A L O G Y,

BY GUSTV. VON ENGESTROM,

DESCRIPTION, &c.

§ 1. **T**HAT Science which teaches us the properties of mineral bodies, and by which we learn how to characterize, distinguish, and class them into a proper order, is called *Mineralogy*. This, like all other sciences, when rightly cultivated, and employed to its proper end (the Public Good), furnishes us with many useful discoveries, in proportion as it increaseth.

§ 2. Though mineralogy has been studied for several ages, yet its progress has been very slow.

Some learned men have, indeed, endeavoured to bring it into some systematical order; But as the passion for only collecting minerals and fossils has still predominated over that of enquiring into the nature of the subjects themselves, they have for the most part met with but very little success. Those who were *mere Collectors*, being superior in number to the *scientific men*, or *true Mineralogists*, and having more opportunities of getting new specimens, were most of them not so communicative to the latter as they ought to have been. Some of these, were wholly taken up in gathering together

together immense heaps of things, seeming almost resolved to get the whole of Nature into their cabinets, without having regard to any true order; while others, proposing to correct this inconvenience, would pretend to some interior knowledge, as if that had been a consequence of their collection; and by that fell into a still greater extravagance.

All this certainly hindered mineralogists from improving much in the science; but, happily, those times are past. The world is grown more reasonable at present, and Mineralogy seems to be more and more encouraged.

The great utility of the mineral bodies already known, promises us a much greater advantage from the study of this science, than the mere pleasure of collecting. But, in order to come at this advantage, we ought to search into the very principles of these bodies, that we may be certain of not deceiving ourselves in our judgement concerning them.

§ 3. As the principal intention of cultivating Mineralogy is to discover the œconomical use of minerals, it is necessary to know every mineral body in regard to all its effects; and thence to determine the best use it might be put to. A System of Mineralogy thus founded on the effects of its subjects, must be more scientific, since it always has in view that valuable point, *their application to Common Life*. And since it is natural to the human mind to adapt every thing to its own advantage

vantage as far as possible, such a system must be more generally received, and at the same time more easily understood, as it includes the mineral bodies in a less number of classes, orders, &c. by which the memory is not so much loaded, as if only their surfaces had been described.

§ 4. This being granted, let us consider what difficulties are to be met with in examining mineral bodies. These often resemble one another in their external appearances, though their constituent parts are quite different, and consequently make them useful in different ways. Most of them require also to be changed from their natural form, and even often dissolved, before they can be made any use of. Their figure and colour, or, in short, their surfaces, are therefore not solely to be depended upon; we must penetrate into them; and they must be decomposed according to the principles of chemistry.

§ 5. By examining the mineral kingdom in this manner, we may now and then find the subjects of our experiments (even if nearly the same) to differ in some of their effects, which is particularly owing to the difficulty of justly determining the degrees of fire employed; a difficulty not yet removed, but which, however, ought not to hinder us from going as far as possibly we can, since we find in practice, that such obstacles are often remedied by repeated experiments; and of these we never can make too many, if judiciously performed.

§ 6. This

§ 6. This method of studying Mineralogy was adopted a considerable time ago: but Mr. Pott, at Berlin, has brought it to a greater perfection: and after him Mr. Cronstedt, in Sweden, extended it yet farther, submitting every mineral body, that came into his possession, to chemical experiments; in consequence of which he afterwards published his *Essay towards a System of Mineralogy*.

§ 7. Thus the greatest obstacle is removed; the best method to learn Mineralogy is laid open, in following which we are enabled to render this Science more and more perfect. To obtain this end, chemical experiments are without doubt necessary; but as a great part of the mineral kingdom has already been examined in this manner, we do not want to repeat all those experiments in their whole extent, unless some new and particular phenomena should discover themselves in the things we are examining; for otherwise the tediousness of those processes might discourage some from going farther, and take up much of the time of others, that might be better employed. An easier way may therefore be made use of, which even for the most part is sufficient, and which, though made in miniature, is yet as scientific as the common manner of proceeding in the laboratories; since it imitates that, and is founded upon the same principles. This consists in *a method of making experiments upon a piece of charcoal with the concentrated flame of a candle urged by air from a Blow-pipe*

pipe [a]. The heat occasioned by this is very intense: and mineral bodies may be thus burned, calcined, melted, or scorified, &c. as well as in any great works.

§ 8. The Blow-pipe is in common use among jewellers, goldsmiths, glass-blowers, &c. and has even been used a little by the chemists and mineralogists; but, to the best of my knowledge, Mr. Cronstedt is the first who made such an improvement in its use, as to employ it in examining all mineral bodies. This gentleman invented some other apparatus, necessary in making the experiments, to go with the Blow-pipe, which all together make a neat little case, that, for its facility of being carried in the pocket, particularly on travels, might be called a *Pocket-Laboratory*: and as neither the Pocket Laboratory, nor even the extensive use of the Blow-pipe, is yet generally known, I think it will not be altogether useless, to give a description of it.

§ 9. The Blow-pipe is represented in its true figure and size, Plate 1, letter Q. D. The globe *b. b.* is hollow, and made on purpose to condense the vapours, which are always accumulated in the Blow-pipe when it has been used some time: if this globe were not there, the

[a] The meaning would be more precise and intelligible, if it had been said, that it is a *method of assaying, by the concentrated flame of a candle, urged by air from a blow pipe, very small pieces of each distinguishable component part of any ore, supported upon a piece of charcoal, or otherwise.* The Editor.

vapours would go directly with the wind out into the flame, and would thereby cool the assay.

The hole in the small end *c.* through which the wind comes out, ought not to be larger than the size of the finest wire. This hole may now and then be stopped up with some small obstacle, which checks the force of the wind; one ought therefore to have a piece of the finest wire, to clear it with when required. And, in order to have this wire the better at hand, a small quantity of it may be packed in an inside corner of the case.

§ 10. In order to determine the most convenient proportions of this instrument, several Blow-pipes of different sizes, both bigger and smaller, have been tried: The former have required too much wind, and the latter being too soon filled with the wind, have returned it back again upon the lungs. Both these circumstances greatly impeded the experiments, and are perhaps even prejudicial to health. This size fig. 1, is found to answer best; and though the hole must be as small as before mentioned (Sect. ix.) yet the sides of the pipe at the point must not be thinner, nor the point narrower than here represented, else it will be too weak, and will not give so good a flame. It is also to be observed, that the canal throughout the pipe, but particularly the hole at the small end, must be made very smooth,

smooth, so that there may be no inequalities in it; as the wind would else be divided, and consequently the flame made double. The Blow-pipe is to be reckoned the best, through which the longest and most pointed flame from off a common-sized candle can be formed. These Blow-pipes are commonly made of brass or silver. See the description and use of the Blow-pipe in the Appendix to this Treatise.

§ 11. *This Section of the Author in the former Edition, consisted of a description of the Articles contained in the Pocket Laboratory. But as all these articles are contained in the Laboratory described in the Appendix to this Treatise, together with others, which the compactness of the arrangement, and the experience of Bergman and other late Chemists have enabled the Editor to add to them; it was thought unnecessary to reprint the present Section. The Editor.*

§ 12. Whenever any substance is to be tried, one must not begin immediately with the Blow-pipe; but some preliminary experiments ought to go before, by which those in the fire may afterwards be directed. For instance, a stone is not always homogeneous, or of the same kind throughout, although it may appear to the eye to be so: The magnifying-glass is therefore necessary, to discover the heterogeneous particles, if there be any; and these ought to be separated, and every part tried by itself, that the effects of two different things, examined together, may not be attributed

to one alone. This might happen, with some of the finer *micæ*, which are now and then found mixed with small particles of quartz, scarcely to be perceived by the eye. The Trapp, (in German *Schwartzstein*) is also sometimes mixed with very fine particles of Felspar (*spatum scintillans*) or of Calcareous Spar, &c. After this experiment, the hardness of the stone in question must be tried with the steel. The Flint and Garnets are commonly known to strike fire with the steel; but there are also other stones, which, though very seldom, are found so hard as to strike fire.

There is a kind of Trapp of that hardness, in which no particles of Felspar are to be seen. Coloured glasses resemble true gems; but as they are very soft in proportion to these, they are easily discovered by the means of the file. The common quartz-crystals are harder than coloured glasses, but softer than the gems. The loadstone discovers the presence of iron, when it is not mixed in too small a quantity in the stone, and often before the stone is roasted. Some kinds of *Hæmatites*, and particularly the *Cærulefcens*, greatly resemble some other iron ores; but this distinguishes itself from them by a red colour, when pounded, the others giving a blackish powder, and so forth.

§ 13. To manage the Blow-pipe with ease requires some practice. A beginner blows generally too strongly, which forces him to
take

take breath very often, and then he draws the flame at the same time along into the Blow-pipe; this is troublesome for himself, and the matter cools always a little at the same time. But more experienced persons can breathe in through the nose, and at the same time blow through the pipe, so as to keep up a constant flame from the candle. The whole art consists in this, that while the air is inspired through the nostrils, that which is contained in the mouth, be forced out through the tube, by the muscular compression of the cheeks; so that the action of the nose, lungs, and mouth, resemble the action of bellows with double partitions. In this manner there is no need of blowing violently, but only with a moderate and equal force, and thus the breath can never fail the operator. The only inconvenience attending it is, that the lips grow weak or tired, after having continued to blow for a considerable time; but they soon recover their former strength, by ceasing to blow for some minutes [a].

§ 14. The candle used for this purpose (Sect. 7.) ought to be snuffed often, but so, that the top of the wick may retain some fat in it, because the flame is not hot enough when the wick is almost burnt to ashes; but

[a] The new form given to the mouth-piece of the improved tube, which has two opposite angular foldings on the outside, fits the lips of the operator so well, as to require a very weak pressure to blow through it. *The Editor.*

only the top must be snuffed off, because a low wick gives too small a flame. The blue flame is the hottest; this ought therefore to be forced out when a great heat is required, and only the point of the flame must be directed upon the subject which is to be assayed*.

§ 15. The piece of charcoal made use of in these experiments (§ 7.) must not be of a disposition to crack. If this should happen, it must gradually be heated until it does not crack any more, before any assay is made upon it. If this is not attended to, but the assay made immediately with a strong flame, small pieces of it will split off in the face and eyes of the assayer, and often throw along with them the matter that was to be assayed. Charcoal which is too much burnt consumes too quick during the experiment, leaving small holes in it, wherein the matter to be tried may be lost: And charcoal that is burnt too little, catches flame from the candle, burning by itself like a piece of wood, which likewise hinders the process.

§ 16. Of those things that are to be assayed, only a small piece must be broken off for

* It is most cleanly and convenient, that the candle be made of wax, and the wick should be thicker than ordinary. It's upper end must be bended (*see fig. 20. plate 2.*) towards the matter intended to be heated, and the stream of air must be directed along the surface of the bended part, so as not absolutely to touch it. *The Essayer.*

that

that purpose, not bigger than that the flame of the candle (§ 7. 14.) may be able to act upon it at once, if required; which is sometimes necessary; for instance, when the matter requires to be made red hot throughout. A piece of about an eighth part of an inch square is reckoned of a moderate size, and fittest for experiments; seldom more, but rather less. This proportion is only mentioned as a direction in regard to the quantity, the figure being of no consequence at all, a piece broken off from a stone seldom or never happening to be square; but here it is to be observed, that the piece ought to be broke as thin as possible, at least the edges. The advantage of this is easily seen, the fire having then more influence upon the subject, and the experiment being more quickly made. This is particularly necessary to be observed when such stones are to be assayed, which although in some respects fusible by themselves, yet resist the action of the fire considerably; because they may by these means be brought into fusion, at least at their edges, which else would have been very difficult, if the piece had been thick.

§ 17. Some of the mineral bodies are very difficult to be kept steady upon the charcoal during the experiment, before they are made red hot; because, as soon as the flame begins to act upon them, they split asunder with violence, and are dispersed. Such often are those

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which

which are of a soft consistence, or a particular figure, and which preserve the same figure in however minute particles they are broke; for instance, the Calcareous Spar, the Sparry Gypsum, Sparry Fluor, White Sparry Lead-ore, the Potters Ore (*Galena tessellata*), the Tessellated Mock-lead or Blende, &c. even all the common fluors which have no determinate figure, and most of the *Mineræ metallorum calciformes crystallisatæ* or *spatosæ*. All these are not so compact as common hard stones; and therefore, when the flame is immediately urged upon them, the heat forces itself through and into their clefts or pores, and causes this violent expansion and dispersion. Many of the clays are likewise apt to crack in the fire, which may be for the most part ascribed to the humidity, of which they always retain a portion. Besides these enumerated, there may be found now and then other mineral bodies of the same nature; but it is, however, not so common.

The only way of preventing this inconvenience is, to heat the body as slowly as possible. It is best, first of all, to heat that place of the charcoal where the piece is intended to be put on, and afterwards lay it thereon; a little crackling will then ensue, but commonly of no great consequence. After that, the flame is to be blown very slowly towards it, in the beginning not directly upon, but somewhat above it, and so approaching nearer and nearer with the flame until it be-
comes

comes red hot. This will do for the most part ; but there are nevertheless some, which, notwithstanding all these precautions, it is almost impossible to keep on the charcoal. Thus the Fluors are generally the most difficult ; and as one of their principal characters is discovered by their effects in the fire *per se*, (§ 18. *f.*) they ought necessarily to be tried that way. To this purpose it is best to make a little hole in the charcoal to put the Fluor in, and then to put another piece of charcoal as a covering upon this, leaving only a small opening for the flame to come in at, and to look at the proof. As this stone will nevertheless split and fly about, a larger piece thereof than is before-mentioned (§ 16.) must be taken, in order to have at least something of it left.

But if the experiment is to be made upon a stone whose effects one does not want to see in the fire *per se*, but rather with fluxes, then a piece of it ought to be forced down into melted borax, (§ 23.) when always some part of it will remain in the borax, notwithstanding the greatest part may sometimes fly away by cracking.

§ 18. As the stones undergo great alterations when exposed to the fire by themselves, whereby some of their characteristicks, and often the most principal, are discovered, they ought first to be tried that way ; observing what has been said before, concerning the quantity of matter, direction of the fire, &c.

The

sometimes found of a dark brown and nearly black colour, but become for all that quite white in the fire, like a piece of China ware. However, care must be taken not to urge the flame from the top of the wick, there being for the most part a sooty smoke, which commonly will darken all that it touches; and if this is not observed, a mistake in the experiment might easily happen. But if it is mixed with iron, as it is sometimes found, it does not so easily part with its dark colour. The Argillaceæ, when mixed with lime, melt by themselves, as above-mentioned (*a*). When mixed with iron, as in the Boles, they grow dark or black; and if the iron is not in too great a quantity, they melt alone into a dark slag; the same happens, when they are mixed with
iron

were fixed in that state in which they form a mass pervious to the light; a phenomenon which is highly deserving of attention, and cannot be performed in a crucible.

Ponderous Earth, exposed alone to the flame, becomes (like calcareous earth) caustic, soluble in water, and deprived of the faculty of effervescing with acids.

In the alkali of soda it effervesces little, but is sensibly diminished.

In borax it is dissolved with a slight effervescence.

It is likewise dissolved in the microscomic salt, but with an ebullition somewhat greater.

The phenomena respecting saturation, which have been noted in calcareous earth, take place likewise in this and other substances.

Magnesia being ignited like the earths already mentioned, but much more easily, it loses the aerial acid, and therefore produces no bubbles by being afterwards applied to acids. It becomes phosphoric after calcination, according to M. Macquer and Lavoisier. But it does not acquire solubility in water by this treatment.

iron and a little of the vitriolic acid, as in the common clay, &c. [b]. c. Mica

In the alkali of soda it effervesces little, and is scarcely at all diminished.

In borax it is dissolved with effervescence.

In the microscopic salt it is likewise dissolved, but with a greater commotion. *Be-gman*. See Note [i] to page 94.

[b] *Common clay* abounds with heterogeneous matters, and always contains at least a portion of siliceous earth, the quantity of which is considerable, being commonly more than half the mass; therefore, when it is required to be pure, it is necessary to make use of the earth of allum carefully washed.

Being ignited, it hardens at the same time that its dimensions are contracted. It is capable of acquiring a flinty hardness by means of ignition.

In the alkali of soda it effervesces a little, but is dissolved in a very small quantity.

Borax takes it up with some effervescence.

The microscopic salt shews a more sensible ebullition.

Siliceous Earth. It is not fusible alone. The alkali of soda dissolves it with a vehement effervescence, and affords a pellucid glass, if the weight of the earth in solution exceeds that of the flux. This experiment, and every other in which the alkali is made use of, must be performed in the spoon.

Borax dissolves it but slowly, and without effervescence.

The microscopic salt very slowly, and without the least ebullition, takes up a portion so small, that it hardly seems to affect it.

Derivative Earths, which are infusible alone.

The Diamond (sometimes decrepitating, and always diminishing by a long continued fire), Pure Asbestos †, Siliceous Hydrophanes, Porcelane Clay †, the Hyacinth, Jasper, Pure Mica †, Quartz, the Ruby, the Sapphire, Flint, Steatite †, the Topaz.

N. B. Those substances which are marked thus †, become hard in the fire.

Infusible Earths which change their colour.

Bolar clays in general become black.

Calcareous earth vitiated with manganese, becomes black.

Calcareous earth, rendered black by a subtle bitumen, becomes white.

Some

e. Mica and Abestos become somewhat hard and brittle in the fire, and are more or less refractory, though they give some marks of fusibility.

f. The Fluors discover one of their chief characteristics by giving a light, like Phosphorus, in the dark, when they are slowly heated; but lose this property, as well as their colour, as soon as they are made red hot. They commonly melt in the fire into a white opaque slag, though some of them not very easily.

g. Some sorts of the Zeolites melt easily and foam in the fire, sometimes nearly as much as Borax, and become a frothy slag, &c.

h. A great many of those mineral bodies which are impregnated with iron, as the Boles, and some of the White Iron Ores, &c. as well as some of the other iron ores, viz. the Bloodstone, are not attracted by the loadstone before they have been thoroughly roasted, &c.

A further digression upon these effects is unnecessary here, their enumeration belonging more properly to Mineralogy; it is sufficient only to have mentioned the most common, in order the better to explain the experiments that are made with the Blow-pipe.

§ 19. After

Some gems either change their colour or lose it. Such are the Chrysolite, the Topaz, and sometimes the Sapphire.

Both the red and green Jasper become white or greyish.

Green, black, and red, steatite, become white.

Earths fusible alone without ebullition,

Asbestus Martialis. Angites, or Aqua Marina †. Basaltes, Fluor mineralis. Chrysolite †. Granite. Marle. Most specimens of the Petrofiliex. Ponderous Spar. Spathum pyromachum, or Feld Spar. The Emerald †. Trapp.

N. B.

§ 19. After the mineral bodies have been tried in the fire by themselves, they ought to be heated with fluxes, to discover if they can be melted or not, and some other phænomena attending this operation. For this purpose three different kinds of salts are used as fluxes, viz. *Sal Sodæ*, *Borax*, and *Sal fusible microscopicum*.

§ 20. The *Sal Sodæ* is a mineral alkali well known, prepared from the herb *Kali* or *Salt-wort*; this salt is however not much used in these small experiments, its effects upon the charcoal rendering it, for the most part, unfit for it; because, as soon as the flame begins to act upon it, it melts instantly, and is almost wholly absorbed by the charcoal. When this salt is employed to make any experiment, but a very little quantity thereof is wanted at once, viz. about the cubical contents of an eighth part of an inch, more or less. This is laid upon the charcoal, and the flame blown on it with the Blow-pipe; but as this salt commonly is in form of a powder, it is necessary to go on very gently, that the force of the flame may not disperse the minute particles of the salt. As soon as it begins to melt it runs along on the charcoal, almost like melted

N. B. Those substances which are marked thus †, are very difficultly brought to exhibit any signs of fusion.

Earths fusible with ebullition.

Lithomarga, or Stone-marle. Schoerl. Zeolite. Tourmalin. *The Editor from Bergman.*

tallow,

tallow, and when cold, it is a glassy matter of an opaque dull colour spread on the coal. The moment it is melted, the matter which is to be tried ought to be put into it, because otherwise the greatest part of the salt will be soaked into the charcoal, and too little of it left for the intended purpose. The flame ought then to be directed on the matter itself; and if the salt spreads too much about, leaving the proof almost alone, it may be brought to it again by blowing the flame on its extremities, and directing it towards the subject of the experiment. If the assays made with this salt, it is true, we may find if the mineral bodies which are melted with it have been dissolved by it or not; but we cannot tell with any certitude whether this is done hastily and with force, or gently and slow; whether only a less or a greater part of the matter has been dissolved; nor can it be well distinguished if the matter has imparted any weak tincture to the slag; because this salt always bubbles upon the charcoal during the experiment; nor is it clear when cool; so that scarcely any colour, except it be a very deep one, can be discovered, although it may sometimes be coloured by the matter that has been tried [a].

§ 21.

[a] *Earths entirely soluble in the alkali of Soda with effervescence.*

Agate. Calcedony. Carnelian. Turkey Stone † (*Cors Turcia*). Fluor Mineralis †. Onyx. Opal. Quartz. Common Flint. Ponderous Spar.

N. B. .

§ 21. The other two salts, viz. Borax, and the Sal fusibile microcosmicum, are very well adapted to these experiments, because they may by the flame be brought to a clear uncoloured and transparent glass; and as they have no attraction to the charcoal, they keep themselves always upon it in a round globular form. The Sal fusibile microcosmicum is very scarce, and perhaps not to be met with in the shops; it is made of urine: Mr. Margraff has given a full account of its preparation in the Memoirs of the Academy of Sciences at Berlin [6].

N. B. *Those articles which are marked with a †, effervesce very little.*

Earths divisible in the alkali of Soda, with or without effervescence; but not entirely soluble.

Amianthus, Asbestus. Basaltes. * Crysolite †.

(N. B. The yellowish crystalline matter, which fills up the interstices of the native Siberian iron, exhibits the same properties, with respect to fire, as the crysolite).

Granate †. Hornblende. Jasper. Marlestone. Mica. The mineral of alun from Tolfa. Petrosilex. Aluminous slate and roof slate, from Helsingia. Emeralds. Steatites: spatum pyromachum. Schoerl. Talc. Trapp. Trippel. Turmalin.

N. B. *Those marked † do not effervesce.*

Earths neither fusible nor divisible in the alkali of Soda.

Diamond. Hyacinth. Ruby. Sapphire. Topaz.

[6] *Earths soluble in Borax, with more or less effervescence.*

Fluor mineralis †. Marle. Mica †. The mineral of Alum from Tolfa. Aluminous Slate and Roof-slate from Helsingia †. Ponderous spar. Schoerl. Talc †. Tourmalin.

N. B. *Those marked † effervesce very little.*

P p p

Earths

§ 22. The quantity of these two salts required for an experiment is almost the same as

Earths soluble in Borax without effervescence.

Agate. Diamond. Amianthus. Asbestos. Basaltes. Calcedony. Cornelian. Chrysolite. Turclea. Granate. Hyacinth †. Jasper. *Lapis ponderosus*. Onyx. Opal. Petrofalex. Quartz †. Ruby. Sapphire. Common flint †. Steatite Spathum pyromachum. Trapp, Trippel, or Tripoli, Topaz. Zeolite. Silicious Hydrophanes.

N. B. *Those marked † require a larger quantity of the salt, and a longer continuance of fire than the rest.*

Earths soluble in the microscomic salt, with more or less effervescence.

Basaltes †. Turkey Stone †. Fluor mineralis †. Mâle Mica. The mineral of alum from Tolfa. Schistus aluminaris; schistus tegularis from Helsingia †. Schoerl. Spathum ponderosum. Turmalin †. *Lapis ponderosus*.

N. B. *Those marked † effervesce very little during solution.*

Earths soluble in the microscomic salt, without visible effervescence.

Agate. Diamond. Amianthus. Asbestos. Calcedony. Cornelian. Chrysolite. Granate. Hyacinth. Jasper. Onyx †. Opal. Petrofalex. Quartz †. Ruby. Sapphire. common flint †. Emerald. Spathum pyromachum. Talc, Topaz, Trapp, Trippel. Zeolite, Hornblend. Siliceous Hydrophanes. Lithomarga. Steatites

N. B. *Those marked † are more difficultly dissolved than the others.*

Calcareous Earth, ponderous Spar, Gypsum, and other additaments, often assist the solution, as well in the microscomic salt, as in borax. To which it is necessary to add, that in order to observe the effervescence properly, the matter added to the flux should be in the form of a small particle rather than in fine powder; because in this last there is always air between the particles, which being afterwards driven off by the heat, affords the appearance of a kind of effervescence. *The Editor from Bergman.*

the

the Sal Sodæ (§ 20.); but as these salts are crystallised, and consequently include a great deal of water, particularly the borax, their bulk is considerably reduced when melted, and therefore a little more of these may be taken than the before-mentioned quantity.

§ 23. Both these salts, (§ 21.) when exposed to the flame of the Blow pipe, bubble very much and foam before they melt to a clear glass, but more especially the borax, which for the most part depends on the water they contain. And as this would hinder the assayer from making due observations on the phenomena of the experiment, the salt which is to be used must first be brought to a clear glass (§ 21.) before it can serve as a flux; it must therefore be kept in the fire until it is become so transparent that the cracks in the charcoal may be seen through it. This done, whatsoever is to be tried, is put to it, and the fire continued.

§ 24. Here it is to be observed, that for the assays made with any of these two fluxes (§ 22.) on mineral bodies, no larger pieces of these must be taken, than that altogether they may keep a globular form upon the charcoal; because it may then be better distinguished in what manner the flux acts upon the matter during the experiment. If this is not observed, the flux, communicating itself with every point of the surface of the mineral body, spreads all over it, and keeps the form of this last, which commonly is flat, (§ 16.) and

by that means hinders the operator observing all the phænomena which may happen. Besides, the flux being in too small a quantity, in proportion to the body to be tried, is too weak to act with all its force upon it. The best proportion, therefore, is about a third part of the mineral body to the flux; and, as the quantity of the flux mentioned in § 20. 22. makes a globe of a due size, in regard to the greatest heat that is possible to procure in these experiments; the size the mineral body proposed in § 16. requires when it is to be tried in the fire by itself is too large on this occasion, the third part of it being here almost sufficient.

§ 25. The Sal Sodæ, as has been said before, is not of much use in these experiments: nor has it any particular qualities in preference to the two last mentioned salts, except that it dissolves the Zeolites easier than the Borax and the Sal fusibile microcosmicum.

This last mentioned salt shews almost the same effects in the fire as the borax, and differs from this in very few circumstances, of which one of the most principal is, that, when melted with manganese, it becomes of a crimson hue, instead of a jacinth colour, which borax takes.

This salt is, however, for its scarcity, still very little in use, borax alone being that which is commonly used. Whenever a mineral body is melted with any of these two last mentioned salts, in the above described manner (§ 22.

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et seq.) it is easily seen whether it is quickly dissolved, because in that case an effervescence arises, which lasts till the whole is dissolved; or whether this is slowly done, in which case few and small bubbles only rise from the matter. Likewise, if it cannot be dissolved at all, because then it is observed only to turn round in the flux, without the least bubble, and the edges look as sharp as they were before.

§ 26. In order further to illustrate what has been said about these experiments, I will mention some instances out of the Mineralogy, concerning the effects of borax upon the mineral bodies, viz.

a. The calcareous substances, and all those stones which contain any thing of lime in their composition, dissolve readily and with effervescence in the borax. The effervescence is the more violent, the greater the portion of lime contained in the stone. This reason, however, is not the only one in the gypsum, because both the constituents of this do readily mix with the borax, and therefore a greater effervescence arises in melting gypsum with the borax, than lime alone.

b. The Siliceæ do not dissolve, unless some few, which contain a quantity of iron.

c. The Argillaceæ, when pure, are not acted upon by the borax; but when they are mixed with some heterogeneous bodies, they are dissolved though very slowly; such is for instance the *Stone Marrow*, the *Common Clay*, &c.

d. The Granateæ, Zeolites, and Trapp, dissolve but slowly.

e. The Fluores, Asbestinæ, and Micaceæ, dissolve for the most part very easily, and so forth.

§ 27. Some of these bodies melt to a colourless transparent glass with the borax; for instance, the *Calcareous* Substances, when pure, the *Fluores*, some of the *Zeolites*, &c. Others tinge the borax with a green transparent colour; viz. the *Granateæ*, *Trapp*, some of the *Argillaceæ*, some of the *Micaceæ* and *Asbestinæ*. This green has its original, partly from a small portion of iron, which the *Granateæ* particularly contain, and partly from phlogiston.

§ 28. The borax cannot dissolve but a certain quantity of a mineral body proportional to its own. Of the calcareous kind it dissolves a vast quantity, but turns at last, when too much has been added, from a clear transparent, to a white, opaque slag. When the quantity of the calcareous matter exceeds but little in proportion, the glass looks very clear as long as it remains hot; but as soon as it begins to cool, a white half opaque cloud is seen to arise from the bottom, which spreads over the third, half, or more of the glass globe, in proportion to the quantity of calcareous matter; but the glass or slag is nevertheless shining, and of a glassy texture when broke; if more of this matter be added, the cloud rises quicker and is more opaque, and
so

so by degrees till the slag becomes quite milk white. It is then no more of a shining, but rather dry appearance, on the surface; is very brittle, and of a grained texture, when broke.

§ 29. All that has been said hitherto of experiments upon mineral bodies, relates only to the stones and earths. I am now proceeding to the metals and ores, in order to describe the manner of examining these bodies, and particularly the management of the Blow-pipe, in these experiments. An exact knowledge and nice proceeding are so much the more necessary here, as the metals are often so disguised in their ores, as to be very difficultly known by their external appearance, and liable sometimes to be mistaken one for the other: Some of the cobalt ores for instance, resemble much the *Pyrites Arsenicalis*; there are also some iron and lead ores, which are nearly like one another, &c.

§ 30. As the ores generally consist of metals mineralised with sulphur or arsenic, or sometimes both together; they ought first to be exposed to the fire by themselves, in order, not only to determine with which of these they are mineralised, but also to set them free from those volatile mineralising bodies: Thus this serves instead of calcination, by which they are prepared for further assays.

§ 31. Here it must be observed, that, whenever any metal, or fusible ore, is to be tried, a

little concavity must be made in that place of the charcoal where the matter is to be put; because, as soon as it is melted, it forms itself into a globular figure, and might then roll from the charcoal, if its surface was plain; but when borax is put to it, this inconveniency is not so much to be feared.

§ 32. Whenever an ore is to be tried, a small bit is broke off for that purpose, of such a size as is directed in § 16: this bit is laid upon the charcoal, and the flame blown on it slowly. Then the sulphur or arsenic begins to part from it in form of smoke; these are easily distinguished from one another by their smell, that of sulphur being sufficiently known, and the arsenic smelling like garlick. The flame ought to be blown very gently as long as any smoke is seen to part from the ore, but, after that, the heat must be augmented by degrees, in order to make the calcination as perfect as possible. If the heat is applied very strongly from the beginning upon an ore that contains much sulphur or arsenic, the ore will presently melt, and yet lose very little of its mineralising bodies, by that means rendering the calcination very imperfect. It is however, impossible to calcine the ores in this manner to the utmost perfection, which is easily seen in the following instance, viz. in melting down a calcined Potter's ore with borax, it will be found to bubble upon the coal, which depends on the sulphur which is still left, the vitriolic acid of this uniting with the borax,
and

and causing this motion. However, lead in its metallic form, melted in this manner, bubbles alone upon the charcoal, if any sulphur remains in it. But, as the lead, as well as some of the other metals, may raise bubbles upon the charcoal, although they are quite free from the sulphur, only by the flames being forced too violently on it, these phænomena ought not to be confounded with each other.

§ 33. The ores being thus calcined, the metals contained in them may be discovered, either by being melted alone, or with fluxes: when they shew themselves, either in their pure metallic state, or by tinging the slag with colour peculiar to each of them. In these experiments it is not to be expected that the quantity of metal contained in the ore should be exactly determined; this must be done in larger laboratories. This cannot, however, be looked upon as any defect, since it is sufficient for a mineralogist, only to find out what sort of metal is contained in the ore. There is another circumstance, which, I am sorry to say, is a more real defect in our little laboratory, which is, that some ores are not at all able to be tried by it, in so small an apparatus: for instance, the gold ore called *Pyrites aureus*, which consists of gold, iron, and sulphur. The greatest quantity of gold, which this ore contains, is about one ounce, or one ounce and an half out of one hundred pounds of the ore, the rest being iron and sulphur;
and

and as only a very small bit is allowed for these experiments, (§ 16. 31.) the gold contained therein can hardly be discerned by the eye, even if it could be extracted; but it goes along with the iron in the slag, this last metal being in so large a quantity in proportion to the other, and both of them having an attraction for each other.

All the Blendes and Black jacks, which are mineral zink ores, containing zink, sulphur, and iron, cannot be tried this way, because they cannot be perfectly calcined; and besides, the zink flies off, when the iron scorifies: neither can all those Blendes, which contain silver or gold mineralised with them, be tried in this manner, which is particularly owing to the imperfect calcination; nor are the quicksilver ores fit for these experiments, the volatility of this semi-metal making it impossible to bring it out of the poorer sort of ores*; and the rich ores, which sweat out the quicksilver when kept close in the hand, not wanting any of these assays, &c. Those ores ought to be assayed in larger quantities, and even with such other methods as cannot be applied upon a piece of charcoal.

§ 34. Some of the rich silver ores are easily tried: for instance, *Minera argenti vitrea*,

* A piece of gold being laid over the proof, to receive the fumes, readily discovers if it contains any quick-silver. And it is probable, that by similar processes we may also be enabled to discover with the Blow-pipe other of the volatile substances.

commonly

commonly called Silver-glass, which consists only of silver and sulphur. When this ore is exposed to the flame, it melts instantly, and the sulphur goes away in fume, leaving the silver pure upon the charcoal, in a globular form. If this silver should happen to be of a dirty appearance, which often is the case, then it must be melted anew with a very little borax, and after it has been kept in fusion for a minute or two, so as to be perfectly melted and red-hot, the proof is suffered to cool: it may then be taken off the coal: and being laid upon the steel-plate, (*Pl. 1. fig. N.*) the silver is separated from the slag by one or two strokes of the hammer (*Pl. 1. fig. E.*). Here the use of the brass ring (*Pl. 1. fig. H.*) is manifest, for this ought first to be placed upon the plate, to hinder the proof from flying off by the violence of the stroke, which otherwise would happen. The silver is then found inclosed in the slag of a globular form, and quite shining, as if it was polished. When a large quantity of silver is contained in a lead ore, viz. in a potter's ore, it can likewise be discovered through the use of the blow-pipe, of which more will be mentioned hereafter. (§. 39.)

§ 35. Tin may be melted out of the pure tin ores, in its metallic state. Some of these ores melt very easily, and yield their metal in quantity, if only exposed to the fire by themselves: but others are more refractory; and as these melt very slowly, the tin, which
sweats

sweats out in form of very small globules, is instantly burnt to ashes, before these globules have time to unite, in order to compose a larger globe, which, might be seen by the eye, is not so soon destroyed by the fire; it is therefore necessary to add a little borax to these from the beginning, and then to blow the flame violently at the proof. The borax does here preserve the metal from being too soon calcined, and even contributes to the readier collecting of the small metallic particles, which soon are seen to form themselves into a globule of metallic tin at the bottom of the whole mass, nearest to the charcoal. As soon as so much of the metallic tin is produced, as is sufficient to convince the operator of its presence, the fire ought to be discontinued, though the whole of the ore is not yet melted; because the whole of this kind of ore can be seldom or never reduced into metal by means of these experiments, a great proportion being always calcined: and if the fire is continued too long, perhaps even the metal already reduced may likewise be burnt to ashes; for the tin is very soon destroyed from its metallic state by the fire.

§ 36. Most part of the lead ores may be reduced to a metallic state upon the charcoal. The *Mineræ Plumbi calciformes*, which are pure, are easily melted into lead; but such of them, as are mixed with an *ochra ferri*, or any kind of earth, as Clay, Lime, &c. yield very little of lead, and even nothing at all, if the hetero-

genea

genea are combined in any large quantity: this happens even with the *Minera plumbi calciformis arsenico mixta*. These, therefore, are not to be tried but in larger laboratories. However, every mineral body suspected to contain any metallic substance may be tried by the blow-pipe, so as to give sufficient proofs whether it contain any or not, by its effects being different from those of the stones or earths, &c.

§ 37. The *Mineræ plumbi mineralisatæ* leave the lead in a metallic form, if not too large a quantity of iron is mixed with it. For example, when a tessellated or steel-grained lead ore is exposed to the flame, its sulphur, and even the arsenic, if there be any, begins to fume, and the ore itself immediately to melt into a globular form; the rest of the sulphur continues then to fly off, if the flame is blown slowly upon the mass; but, on the contrary, very little of the sulphur will go off, if the flame is forced violently on it: in this case, it rather happens that the lead itself crackles and dissipates, throwing about very minute metallic particles. The sulphur being driven out as much as possible, which is known by finding no sulphureous vapour in smelling at the proof, the whole is suffered to cool, and then a globule of metallic lead will be left upon the coal. If any iron is contained in the lead ore, the lead, which is melted out of it, is not of a metallic shining, but rather of a black and uneven surface: a little borax must in
this

this case be melted with it, and as soon as no bubble is seen to rise any longer from the metal into the borax, the fire must be discontinued: when the mass is grown cold, the iron will be found scorified with the borax, and the lead left pure, and of a shining colour.

§ 38. Borax does not scorify the lead in these small experiments, when it is pure: if the flame is forced with a violence on it, a bubbling will ensue, resembling that which is observed when borax dissolves a body melted with it; but, when the fire ceases, the slag will be perfectly clear and transparent, and a quantity of very minute particles of lead will be seen spread about the borax, which have been torn off from the mass during the bubbling.

§ 39. If such a lead ore (§ 37.) is rich in silver, this last metal may likewise be discovered by this experiment; because, as the lead is volatile, it may be forced off, and the silver remain. To effect this, the lead, which is melted out of the ore, must be kept in constant fusion with a slow heat, that it may be consumed. This end will be sooner obtained, and the lead part quicker, if, during the fusion, the wind through the blow-pipe is directed immediately, though not forcibly, upon the melted mass itself, until it begins to cool, at which time the fire must be directed on it again. The lead, which is already in a volatilising state, will by this artifice be driven out in form of a subtil smoke; and by thus continuing by turns to melt

melt the mass, and then to blow off the lead, as has been said, until no smoke is any longer perceived, the silver will at last be obtained pure. The same observation holds good here also, which was made about the gold, that, as none but very little bits of ores can be employed in these experiments, it will be difficult to extract the silver out of a poor ore; for some part of it will fly off with the lead, and, what might be left, is too little to be discerned by the eye. The silver, which, by this means is obtained, is easily distinguished from lead by the following external marks, viz. that it must be red-hot before it can be melted: it cools sooner than lead: it has a silver colour; that is to say, brighter and whiter than lead: and is harder under the hammer. (§ 34.)

§ 40. The *Mineræ cupri calciformes* (at least some of them) when not mixed with too much stone or earth, are easily reduced to copper with any flux; if the copper is found not to have its natural bright colour, it must be melted with a little borax which purifies it. Some of these ores do not at all discover their metal, if not immediately melted with borax; the heterogenea, contained in them, hindering the fusion, before these are scorified by the flux.

§ 41. The grey Copper ores, which only consist of copper and sulphur, are tried almost in the same manner as above mentioned. (§ 40.) Being exposed to the flame by themselves, they will be found instantly to melt,

and part of their sulphur to go off. The copper may afterwards be obtained in two ways; the one, by keeping the proof in fusion for about a minute, and afterwards suffering it to cool; when it will be found to have a dark and uneven appearance externally, but which, after being broke, discovers the metallic copper of a globular form in its centre, surrounded with a regulus, which still contains some sulphur and a portion of the metal: the other, by being melted with borax, which last way sometimes makes the metal appear sooner.

§ 42. The *Mineræ cupri pyritaceæ*, containing copper, sulphur, and iron, may be tried with the blow-pipe, if they are not too poor. In these experiments the ore ought to be calcined, and, after that, the iron scorified. For this purpose a bit of the ore must be exposed to a slow flame, that as much of the sulphur as possible may part from it before it is melted, because the ore commonly melts very soon, and then the sulphur is more difficultly driven off. After being melted, it must be kept in fusion with a strong fire for about a minute, that a great part of the iron may be calcined; and, after that, some borax must be added, which scorifies the iron, and turns with it to a black slag. If the ore is very rich, metallic copper will be had in the slag, after the scorification: if the ore is of a moderate richness, the copper will still retain a little sulphur, and sometimes iron: the product will therefore be brittle, and must with great caution

tion be separated from the slag, that it may not break into pieces: and if this product is afterwards treated in the same manner as before said, in speaking of the grey copper-ores (§ 41.), the metal will soon be produced. But, if the ore is poor, the product after the first scorification must be brought into fusion, and afterwards melted with some fresh borax, in order to calcine and scorify the remaining portion of iron; after which it may be treated as mentioned in Sect 41. The copper will, in this last case, be found in a very small globule.

§ 43. The copper is not very easily scorified with this apparatus, when it is melted together with borax; unless it has first been exposed to the fire by itself for a while, in order to be calcined. When only a little of this metal is dissolved, it instantly tinges the slag of a reddish brown colour, and mostly opaque; but as soon as this slag is kept in fusion for a little while, it becomes quite green and transparent: and thus the presence of the copper may be discovered by the colour, when it is concealed in heterogeneous bodies, so as not to be discovered by any other experiment.

§ 44. If metallic copper is melted with borax by a slow fire, and only for a very little time, the glass, or slag, becomes of a fine transparent blue or violet colour, inclining more or less to the green; but this colour is not properly owing to the copper, but it may

rather
Q q q

rather be to its phlogiston; because the same colour is to be had in the same manner from iron: and these glasses, which are coloured with either of these two metals, soon lose their colour, if exposed to a strong fire, in which they are made quite clear, and colourless. Besides, if this glass, tinged blue with the copper, is again melted with more of this metal, it becomes of a good green colour, which for a long time keeps unchanged in the fire.

§ 45. The iron ores, when pure, can never be melted by themselves, through the means of the blow-pipe alone, nor do they yield their metal, when melted with fluxes, because they require too strong a heat to be brought into fusion; and, as both the ore and the metal itself very soon lose the phlogiston in the fire, and cannot be supplied with a sufficient quantity from the charcoal, so likewise they are very soon calcined in the fire. This easy calcination is also the reason why the fluxes, for instance borax, readily scorify this ore, and even the metal itself. The iron loses its phlogiston in the fire sooner than the copper, and is therefore easier scorified; and this is the principle on which the experiment mentioned in Sect. 42 is founded.

§ 46. The iron is, however, discovered without much difficulty, although it were mixed but in a very small quantity with heterogeneous bodies. The ore, or those bodies
which

which contain any large quantity of the metal, are all attracted by the loadstone, some without any previous calcination, and others without having being roasted. When a clay is mixed with a little iron, it commonly melts by itself in the fire; but, if this metal is contained in a limestone, it does not promote the fusion, but gives the stone a dark, and sometimes a deep black colour, which always is the character of iron. A *Minera ferri calciformis pura crystallisata*, is commonly of a red colour: This being exposed to the flame, becomes quite black, and is then readily attracted by the loadstone, which it was not before. Besides these signs, the iron discovers itself, by tinging the slag of a green transparent colour, inclining to brown, when only a little of the metal is scorified; but as soon as any larger quantity thereof is dissolved in the slag, this becomes first a blackish brown, and afterwards quite black and opaque.

§ 47. Bismuth is known by its communicating a yellowish brown colour to borax: and arsenic by its volatility, and garlick smell. Antimony both in form of regulus and ore, is wholly volatile in the fire, when it is not mixed with any other metal (except arsenic), and is known by its particular smell; easier to be distinguished, when once known, than described. When the ore of antimony is melted upon the charcoal, it bubbles constantly, during its volatilising.

§ 48. Zinc ores are not easily tried upon the coal (Sect. xxxiii.). But the regulus of zinc, exposed to the fire upon the charcoal, burns with a beautiful blue flame, and forms itself almost instantly into white flowers, which are the common flowers of zinc.

§ 49. Cobalt is particularly remarkable for giving to the glass a blue colour, which is the zaffre or smalt. To produce this, a piece of cobalt ore must be calcined in the fire (Sect. 30. 31.) and afterwards melted with borax. As soon as the glass, during the fusion, from being clear, seems to grow opaque, it is a sign, that it is already tinged a little; the fire is then to be discontinued, and the operator must take hold with the nippers (Pl. 1. *fig. R.*) of a little of the glass, whilst yet hot, and draw it out slowly in the beginning, but afterwards very quick, before it cools, whereby a thread of the coloured glass is procured, more or less thick, wherein the colour may easier be seen against the day or candle-light, than if it was left in a globular form. This thread melts easily, if only put in the flame of the candle, without the help of the blow-pipe.

If this glass is melted again with more of the cobalt, and kept in fusion for a while, the colour becomes very deep; and thus the colour may be altered at pleasure.

§ 50. When the cobalt ore is pure, or at least contains but little iron, a cobalt regulus is almost instantly produced in the borax, during

ing the fusion; but when it is mixed with a quantity of iron, this last metal ought first to be separated, which is easily performed, since it scorifies sooner than the cobalt; therefore, as long as the slag retains any brown or black colour Sect 49. it must be separated, and melted again with fresh borax, until it shews the blue colour.

§ 51. Nickel is very seldom to be had, and as its ores are seldom free from mixtures of other metals, it is very difficultly tried with the blow-pipe. However, when this semi-metal is mixed with iron and cobalt, it is easily freed from these heterogeneous metals, and reduced to a pure nickel regulus by means of scorification with borax, in the same manner as is mentioned Sect I. because both the iron and cobalt sooner scorify than the nickel. The regulus of nickel itself is of a green colour, when calcined: it requires a pretty strong fire before it melts, and tinges the borax with a hyacinth colour. Manganese gives the same colour to borax, but its other qualities are quite different, so as not to be confounded with the nickel [a].

§ 52.

[a] *The habitudes of mineralized metals in the fire.* When metals are dissolved in a natural menstruum, especially sulphur, I call them mineralized. I am aware that many use the term mineralization in a very extended sense, so that they apply it not only to those conjunctions of metals especially, of which arsenic is a part, but even to the mechanical implication of earths or stones. But if arsenic be reckoned a

§ 52. Thus I have briefly described the use of the Blow-pipe, and the method of employing

mineralizing substance, it is obvious that we must, as a consequence, allow of no native metals. For each of these are debased with some other metal, Gold, for example, with silver or copper, platina with iron, silver with gold or copper, and so of the rest. If therefore metals can be mineralized by arsenic, why not by other metals?

Sulphurated metals may be freed from their sulphur by a slight roasting upon the charcoal, or at least the greatest part may be driven off. The mineral must not be fused, for the surface in that case becoming much less, the mineralizing matter is much longer in flying off.

The several volatile matters are known by their smell, fume, or cloudy tinge around them; and the fixed residues being fused by the help of the fluxes, their contents may be known partly by their colour, partly by the reduced particles, and lastly by the precipitation they afford upon iron.

Mineralized Gold. Gold cannot be directly united with sulphur; but they are found together in the form of golden pyrites by the mediation of iron, which is strongly attractive of both. But this mineral contains the gold in so small a quantity, that though it may be separated by fusion and scorification, yet as it scarcely exceeds $\frac{1}{1000}$ part of the weight of the particle examined by the blow-pipe, it may easily escape observation by being enveloped in the scoria.

Mineralized Silver. Sulphurated silver, or the vitreous silver ore, being fused on the charcoal, becomes deprived of its mineralizing matter without difficulty; so that a bright globule is often produced, which may be purified, if necessary, with borax. Copper, iron, or manganese, deprive silver of its sulphur.

If arsenic be present, together with sulphur, as in the red ore of silver, both may be driven off by a slight roasting, and the regulus must then be entirely freed from heterogeneous matters by the help of borax.

A mixture of copper, sulphur, arsenic, and silver, or the white silver ore, exhibits a globule, which is rendered impure by these metals.

Silver,

employing it in the study of Mineralogy. Any gentleman, who is a lover of this science, will,

Silver, loaded with sulphur and lead (galena), loses its sulphur by roasting, after which the lead may be gradually destroyed by repeated fusions and coolings, or it may be separated in the cupel.

Mineralized Lead. Galena affords a distinct regulus on the charcoal, unless it be too much loaded with iron. The lead is precipitated by iron and copper.

Mineralized Copper. This mineral, which is termed the *cinereous*, or more improperly *the vitreous* ore of copper, being gently roasted with care, and at last fused, exhibits a mass, whose exterior crust is usually contaminated with sulphur; but whose interior part is pure copper, if the fusion has been sufficiently made. The roasted mass in general affords the regulus more speedily by the addition of borax. Cupreous pyrites always abounds with iron: this, after a proper roasting, being sufficiently fused, affords a regulus of copper, if the ore be rich; but if poorer it requires frequent scorifications with borax. But if the mass be fused together with borax upon iron, vestiges of copper are precipitated, though very small. The celebrated Galin has discovered, that if the flame be thrown suddenly and by intervals, on a calcined grain of copper ore, the metallic splendor appears on its surface at those instants, which at other times is black.

Mineralized Iron. Sulphurated iron, commonly known by the name of pyrites, may be melted into a globule, which, at the beginning, is environed with a bluish flame. But because the metal itself is easily deprived of its phlogiston and scorified, it exhibits no regulus, either alone, or when treated with borax.

Mineralized Bismuth. Bismuth exhibits a blue flame when fused.

This ore of bismuth fused with borax is distinctly precipitated by iron or manganese.

Mineralized Nickel. Sulphurated Nickel has not yet been found, without an addition of iron and arsenic. By roasting and frequent fusions with borax, the regulus is obtained, but scarcely, if ever, free from foreign matter.

will, by attending to the rules here laid down, be able in any easy manner to amuse himself in discovering the properties of those works of nature which the mineral kingdom furnishes us with. The husbandman may by its help find out what sorts of stones, earths, ores,

Mineralized Cobalt. What we have said of Nickel is likewise true of sulphurated cobalt. At least it is never without iron, and seldom free from arsenic. The regulus may be obtained upon the charcoal, by the method just mentioned, but always vitiated by heterogeneous matters.

Mineralized Zinc. Though Zink refuses any direct union with sulphur, yet they are found joined in the same mineral, and that especially by the mediation of iron. The mineral, which is called *Blende*, is without metallic splendor, melts by itself upon the coal, commonly tinging the flame after the manner of zink. It is dissolved both in borax and the phosphoric salt. That mineral of zinck, which possesses the metallic splendor has the same properties, but seems to melt or be dissolved more easily. Both these leave a cloudiness upon the charcoal.

Mercury, Arsenic, and Antimony. Mercury, arsenic, and antimony, are volatile in the state of mineralization. The first is found in the form of cinnabar, which melts on the charcoal, exhibits a blue flame, and gradually exhales without having any residue.

Yellow Arsenic, exposed to the exterior flame in such a manner that it may neither melt nor fume, becomes red, but returns to its original yellowness when cool: if it be urged so as just to begin to melt, it acquires a redness which persists even when cold; if a stronger fire be applied, it flies entirely away. Rissigal contains a somewhat greater portion of sulphur, and therefore more easily melts, but it flies away totally like the other.

Crude Antimony upon the charcoal melts, fumes, is imbibed, and at last totally vanishes, except a cloudiness about the spot it rested on.

Platina and *Tin* are scarcely found sulphurated in the bowels of the earth. *The Editor from Bergman.*

&c.

&c. there are on his estate, and to what economical uses they may be employed. The Scientific Mineralist may, by examining into the properties and effects of the mineral bodies, discover the natural relation these bodies stand in to each other, and thereby furnish himself with materials for establishing a Mineral System, founded on such principles as Nature herself has laid down in them; and this in his own study, without being forced to have recourse to great laboratories, crucibles, furnaces, &c. which is attended with much trouble, and is the reason why so few can have an opportunity of gratifying their desire of knowledge in this part of natural history. I shall now add some hints towards the improvements of this apparatus, leaving to the judicious practitioner the task of completing them.

§ 53. A great number of fluxes might, perhaps, be found out, whose effects on mineral bodies might be different from those already in use, whereby more distinct characters of those mineral bodies might be discovered, which now either shew ambiguous ones, or which it is almost impossible to try exactly with the Blow-pipe. Instead of the *sal sodæ*, some other salt might be discovered better adapted to these experiments. But it is very necessary not to make use of any other fluxes on the charcoal than such as have no attraction to it: if they, at the same time, are clear and transparent, when melted, as the borax and the

sal fusibile microcosmicum, it is still better: however, the transparency and opacity are of no great consequence, if a substance is essayed only in order to discover its fusibility, without any attention to its colour; in which case, some metallic slag, perhaps, might be useful.

§ 54. When such ores are to be reduced whose metals are very easily calcined, such as tin, zinc, &c. it might perhaps be of service to add some phlogiston, since the charcoal cannot afford enough of it in the open fire of these essays: such a phlogiston might be hard resin, or some such body. The manner of melting the volatile metals out of their ores *per descensum* might also, perhaps, be imitated: for instance, a hole might be made in the charcoal, wide above, and very narrow at the bottom; a little piece of the ore being then laid at the upper end of the hole, and covered with some very small pieces of the charcoal, the flame must be directed on the top: the metal might, perhaps, by this method, run into the hole below, concealed from the violence of the fire, particularly if the ore is very fusible, &c.

Several of my experiments have indeed induced me to believe the possibility of these improvements; but as I have not yet had an opportunity of bringing them to perfection, I will not deliver them as infallible: these hints are only communicated as an inducement to farther trials.

§ 55.

§ 55. The use of the Pocket Laboratory, as here described, is chiefly calculated for a travelling mineralist. But a person, who always resides at one and the same place, may by some alteration make it more commodious to himself, and avoid the trouble of blowing with the mouth. For this purpose he may have the Blow-pipe go through a hole in a table, and fixed underneath to a small pair of bellows with double bottoms, such as some of the glass-blowers use, and then nothing more is required, than to move the bellows with the feet during the experiment; but in this case a lamp may be used instead of a candle. This method would be attended with a still greater advantage, if there were many such parts as *c c* fig. *Q. Pl. 1.* the opening of which were of different dimensions: those parts might by means of a screw be fastened to the main body of the Blow-pipe, and taken away at pleasure. The advantage of having these nozzles, if I may be permitted to call them so, of different capacities at their ends, would be that of exciting a stronger or weaker heat as occasion might require. It would only be necessary to observe, that in proportion as the opening of the pipe (nozzle) is enlarged, the quantity of the flame must be augmented by a thicker wick in the lamp, and the force of blowing encreased by means of weights laid on the bellows, a much intenser heat would thus be produced by a pipe of a considerable opening at the end, by which the experiments must undoubtedly be carried

carried farther than with the common Blow-pipe.

§ 56. A traveller, who has seldom an opportunity of carrying many things along with him, may very well be contented with this Pocket-Laboratory, and its apparatus, which is sufficient for most part of such experiments as can be made on a journey. There are, however, other things very useful to have at hand on a journey, which ought to make a second part of the Pocket-Laboratory, if the manner of travelling does not oppose it: this consists of a little box including the different acids, and one or two matrasses, in order to try the mineral bodies in liquid menstrua, if required.

§ 57. These acids are, the Acid of Nitre, of Vitriol, and of Common Salt. Most of the stones and earths are attacked, at least in some degree, by the acids; but the calcareous are the easiest of all to be dissolved by them, which is accounted for by their calcareous properties. The acid of nitre is that which is most used in these experiments; it dissolves the limestone, when pure, perfectly, with a violent effervescence, and the solution becomes clear; when the limestone enters into some other body, it is nevertheless discovered by this acid, through a greater or less effervescence in proportion to the quantity of the calcareous particles, unless there are so few as to be almost concealed from the acid by the heterogeneous ones. In this manner a calcareous body, which sometimes nearly resembles a siliceous

aceous or argillaceous one, may be known from these latter, without the help of the Blow-pipe, only by pouring one or two drops of this acid upon the subject; which is very convenient when there is no opportunity, nor time, of using this instrument.

§ 58. The Gypsa, which consist of lime and the vitriolic acid, (§ 18. 12.) are not in the least attacked by the acid of nitre, if they contain a sufficient quantity of their own acid, because the vitriolic acid has a stronger attraction to the lime, than the acid of nitre: but if the calcareous substance is not perfectly saturated with the acid of vitriol, then an effervescence arises with the acid of nitre, more or less in proportion to the want of the vitriolic acid. These circumstances are often very essential in distinguishing the *calcareæ* and *gypsa* from one another.

§ 59. The acid of nitre is likewise necessary in trying the zeolites, of which some species have the singular effect to dissolve with effervescence in the abovementioned acid; and within a quarter of an hour, or even sometimes not until several hours after, to change the whole solution into a clear jelly, of so firm a consistence, that the glass, wherein it is contained, may be reversed, without its falling out.

§ 60. If any mineral body is tried in this menstruum, and only a small quantity is suspected to be dissolved, though it was impossible to distinguish it with the eye during the solution,

tion, it can be easily discovered by adding to it *ad saturitatem* a clear solution of the alcali, when the dissolved part will be precipitated, and fall to the bottom. For this purpose the *sal sodæ* (§ 20.) may be very useful.

§ 61. The acid of nitre will suffice for making experiments upon stones and earths; but if the experiments are to be extended to the metals, the other two acids (§ 57.) are also necessary. As the acids are very corrosive, they must not be kept in the ordinary Pocket-Laboratory, already described, for fear of spoiling the other apparatus, if the stoppers should happen not to fit exactly to the necks of the bottles, and any of the acid should be spilt.

The Sections 62. and 63. contained a description of the humid apparatus of the author. They are omitted, because a more extensive and compact apparatus is described in the appendix.

§ 64. Another instrument is likewise necessary to a complete Pocket-Laboratory; viz. a Washing-trough, in which the mineral bodies, and particularly the ores, may be separated from each other, and from the adherent rock, by means of water.

This trough is very common in laboratories, and is used of different sizes; but here only one is required of a moderate size, such as twelve inches and a half long, three inches broad at the one end, and one inch and a half at the other end, sloping down from the sides and the broad end to the bottom, where it is three quarters of an inch deep: I have given a

figure of it in Plate 2. *fig. 22* *. of one *fourth* or *third* of the usual size. It is commonly made of wood, which ought to be chosen smooth, hard, and compact, wherein are no pores in which the minute grains of the pounded matter may conceal themselves.

It is to be observed, that if any such matter is to be washed, as is suspected to contain some native metal, such as silver or gold; a trough should be procured for this purpose, of a very shallow slope; because the minute particles of the native metal have then more power to assemble together at the broad end, and separate from the other matter.

§ 65. The management of this trough, or the manner of washing, which I suppose to be known before, consists in this. That when the matter is mixed with about three or four times its quantity of water in the trough, this is kept very loose between two fingers of the left hand, and some light strokes given on its broad end with the right, that it may move backwards and forwards, by which means the heaviest particles assemble at the broad and lower end, from which the lighter ones are to be separated by inclining the trough and pouring a little water on them. By repeating this process, all such particles as are of the same gravity may be collected together, and separate from those of different gravity, provided they were before equally

* The trough which forms part of the apparatus described in the Appendix, is of much smaller dimensions than here described.

pounded;

pounded : though such as are of a clayey nature, are often very difficult to separate from the rest, which, however, is of no great consequence to a skilful and experienced washer. The washing process is very necessary, as there are often rich ores, and even native metals, found concealed in earths and sand in such minute particles, as not to be discovered by any other means.

APPENDIX

APPENDIX THE FIRST.

A DESCRIPTION

OF THE

POCKET-LABORATORIES

FOR

ASSAYING MINERALS,

BY THE EDITOR.

1st. *The Dry Laboratory.*

1. **T**HE Pocket-Laboratories are so called on account of their size, which is about that of an octavo book, for the convenience of carriage by traveling mineralogists, either in the pocket, or in the portmanteau. They contain the chief implements and materials required for the immediate trial and examination of fossil substances, whether recently obtained, or kept under erroneous denominations in various collections of Natural History; a circumstance that often happens through the unskillfulness of the owners.

R r r

2. The

2. The great advantage of this kind of miniature essays is very obvious, and they are often much more advantageous, than experiments made at large in Chemical Laboratories. Mr. Engestrom has made several observations on this subject in the first sections of his treatise, to which may be here added, that by this method such phænomena are distinctly observed, as are necessarily lost in the large processes; for the assayer has under his eyes the progress of changes and transient phænomena caused by fire on every substance: which cannot be observed in a large furnace. Besides this circumstance, there are often specimens so rare, and so much esteemed by the owners, that the smallest pieces are not obtained but with difficulty, to determine their real contents; for as to their external appearances, no one can ever reasonably depend on them [a].

3. The names of those great Mineralogists, who have contrived and improved these travelling apparatus, need only be mentioned, to shew the decided advantages and great utility of such essays: these are the famous Andreas Swab, who first applied the blow-pipe to the examination of minerals, as Bergman observes;

[a] The external appearances, configurations, colours, and consistency of mineral bodies, are often promiscuously ascribed to various fossils, and are of course so incapable of affording a knowledge of any individual substance of the fossil kind, that I can hardly form a notion how any reflecting person, not led away by a disposition for childish amusement, could ever attempt to mislead the public with a mineralogical system, grounded on such uncertain principles.

His celebrated scholar, our Author, Mr. Cronstedt, and after him Rinman, Quist, Engeström, Scheele, Gahn, and Bergman himself, all from Sweden, where the knowledge of mineralogy has been pursued with indefatigable zeal: and lastly, the celebrated Mr. de Morveau of Dijon, who is now disclosing with the greatest success the abstruse recesses of Modern Chemistry to the French nation.

4. The chief pieces and implements of the Pocket-Laboratories are represented in the two annexed plates. The first contains the whole *Dry Laboratory*, so called on account of its containing whatever is required to try all kinds of fossils in the *dry way* by fire, without any of the *humid menstrua*. It consists of a box as large as an octavo book, lined with green velvet, and covered with black fish-skin. It is $8\frac{1}{4}$ inches long, 6 broad, and $1\frac{1}{2}$ inches deep, outside measure. The inside is divided into different compartments, by thin partitions, which are continued to the bottom, in order to contain some other implements under those represented in the quadrangular figure C. F. N. of the first plate, that are seen on opening the box.

5. D and Q are the two pieces that form the *blow-pipe*, which is represented entire at the bottom of the plate, marked by the same letters. This very useful instrument has been considerably improved of late in England. The mouth-piece *aa* is made of ivory, to avoid the disagreeable sensation of having a piece of

R r r 2

metal

metal a long time between the teeth and lips, which, if not of silver or gold, may be very noxious to the operator, a circumstance that has been hardly noticed before. The other improvements of this useful instrument are mentioned in the Note [b].

6. The

[b] It is rather extraordinary that the Blow-pipe has been considerably deficient in many respects, although it has been used from time immemorial by various artists, as *gold-smiths, jewellers, glass-blowers*, and many others; and even after having been adopted by many able and ingenious persons for mineralogical experiments. It is no matter of what metal the blow-pipe is made: brass is the most commonly used; but it may be made of *silver* or *gold*, according to the fancy of the owner, provided it possesses the good qualities required.

1. If the mouth-piece *aa* be made of a round form, it cannot be held for any length of time between the teeth and lips, to blow through it, without straining the muscles of the mouth, which produces a painful sensation. It must therefore have such an external figure, as to adapt itself accurately to the lateral angles of the lips, having a flattish oval form externally, with two opposite corners to fit those internal angles of the mouth, when it is held between the lips, as may be seen in that represented in the figure at the bottom of plate I.

2. The small globe *bb* is hollow, for receiving the moisture of the breath, and must be composed of two hemispheres, exactly screwing into one another in *bb*; the male-screw is to be in the lower part, and soldered on the crooked part *Q*, of the tube *QD*. at such a distance, that the inside end of the crooked tube be even with the edge of the hemisphere, as represented by the pointed lines in the figure. But the upper hemisphere is to be soldered at the end of the straight tube *D*. By these means, the moisture arising from the breath falls into the hollow of the lower hemisphere, where it is collected round the upper inside end of the crooked part *Q*, of the blow-pipe, without being apt to fall into it.

3. The

6. The stream of air that is impelled by the blow-pipe, as seen in fig. 3. plate II. upon the flame, must be constant and even; and must last as long as the experiment continues to require it. This labour will fatigue the lungs, unless an equable and uninterrupted inspiration can at the same time be continued. To succeed in this operation without inconvenience, some labour and practice are necessary. The whole artifice, however, consists in this, *viz.* that, while the air is inspired through the nostrils, that part which is contained in the mouth be augmented at each expiration, and constantly forced out through the blow-pipe by the muscular compression of the cheeks. The comparison of this operation to that of a

3. The small nozles, or hollow conical tubes, advised by Messieurs Engeltrom, Bergman, and others, are wrong in the principle; because the wind that passes from the mouth through such long cones, loses its velocity by the lateral friction, as happens in hydraulic spouts, which, when formed in this manner, do never throw the fluid so far, as when the fluid passes through a hole of the same diameter, made in a thin plate of a little metallic cap that screws at the end of the large pipe. It is on this account that the little cap *c* is employed, having a small hole in the thin plate, which serves as a cover to it; and there are several of these little caps, with holes of smaller and larger sizes, to be changed and applied, whenever a flame is required to be more or less strong.

4. Another conveniency of these little caps is, that even in case any moisture should escape falling into the hemisphere *bb*, and pass along with the wind through the crooked pipe *Q*, it never can arrive at, nor obstruct the little hole of the cap *c*, there being room enough under the hole in the inside, where this moisture must be stopped, till it is cleaned and wiped out.

R r r 3

double

double bellows is exactly true; but that of the piston in the air-pump, as some pretenders have hinted, is quite absurd.

7. Some persons may find this operation considerably difficult; but frequent trials will establish the habit, so that an uninterrupted stream of air can be emitted through the blow-pipe during one quarter of an hour, and even much longer, without any considerable fatigue, as I have experienced myself.

8. This stream of air is required to impel the flame upon the matter under examination. Too great a flame does not yield to the blast; and too small a one produces a weak effect. A slender candle should therefore be chosen, with a cotton wick. The burnt top must be cut off at such a length, that the remainder may be bent a little to near a right angle, as it appears by *a b* fig. 20. pl. II; and the same is represented also by the flame of fig. 3. The orifice *i* of the blow-pipe is to be held above, and near this bent part, in a perpendicular position to the wick, and then the air must be as regularly expelled, as possible. See § 13. p. 932.

9. The flame being thus forced sideways by the violence of the blast, exhibits two distinct appearances: the internal *e* (fig. 20. plate. II.) is conical, well defined, and of a blue colour; at the apex of this, the most violent degree of heat is excited: but the external flame *c d* is of a brownish, vague, and undetermined hue, which is deprived of its phlogiston by the surrounding atmosphere, and produces a much
less

less heat at its extremity than the interior bluish flame. It is therefore the apex of this internal blue flame that must be directed to the subject which is required to be assayed; as it appears by *m* in fig. 2. pl. II.

10. But every assay is always to begin by the exterior flame, which must be first directed upon the mass under examination: and when its efficacy is well known, then the interior blue flame is to be employed.

11. Particular care must be taken to observe, whether the matter *decrepitates, splits, swells, liquefies, boils, vegetates, changes colour, smokes, is inflamed, becomes oily or magnetic, &c.* See § 18. p. 937. and the Notes.

12. The piece exposed to the flame should scarcely ever exceed the bulk of a middle-sized grain of pepper; but it ought never to be so small as not to be capable of being taken up by the tongs or forceps marked R pl. I. If it be too large, a part of it is necessarily out of the focus, and must cool both the support and the part immersed in the blue apex of the flame, as is said already at § 16. p. 934.

13. After the ore is roasted, it is to be pounded upon the steel plate marked N. plate I. by the hammer E. the particles being prevented from being dissipated by the ring H, within which the pieces to be broken are to be put.

14. A small piece should always be added separately to each of the fluxes, concerning which it must be observed, whether it dissolves

R r r 4

wholly,

wholly, or only partially? whether this be effected with, or without effervescence? quickly, or slowly? whether the mass be divided into powder, or gradually and externally corroded? what colour the glass is tinged by, whether opaque or pellucid? as has been already observed.

15. C. represents a wax-candle to be lighted for these trials, as being the most cleanly, although any other candle of tallow, or an oil-lamp, and still better a lamp with burning spirits of wine, may be made use of for the same purpose.

16. F. pl. I. is a round plate of brass, with a prong *d* in the middle, to serve as a candle-stick to hold the candle C. It has various concentrical grooves, to hold the solid different results of the experiments apart from each other. The space under the round plate C, which has the prong turned downwards, is filled by one or two small pieces of charcoal for serving as supports in the trials.

17. The three phials A. B. M. contain the three fluxes that are fit for these experiments; viz. the microcosmic or phosphoric *acid* is contained in that marked M. It is an acid already described, Sect. 164, and is partly saturated with *mineral*, and partly with *volatil* alkali, and loaded besides with much water, and a gelatinous fat. When exposed to the flame, upon the charcoal, it burns and foams violently, with a continual crackling noise, until the water and volatil alkali have flown off.

off. Afterwards it is less agitated, sending forth somewhat like black scoriæ, arising from the burnt gelatinous part. These are soon dispelled, and a pellucid sphaerula, encompassed by a fine green cloud, is exhibited, being occasioned by the deflagration of the phosphorus arising from the extraction of the acid by means of the inflammable matter.

The clear globule which remains, upon the removal of the flame, continues longer soft than that formed by the borax, and therefore is more fit for the addition of the matter to be dissolved. The volatil alkali is soon expelled by the fire; therefore an excess of acid arises in what remains, which easily attracts moisture in a cool place.

18. The mineral alkali in the phial A, called otherwise *Sal Sodæ*, and described in Sect. 170, if fused upon the charcoal, melts superficially, with a cracking noise, penetrates the charcoal, and disappears. It is on this account that it is employed in the silver-spoon, marked P. on the outside of the Pl. I. but which is packed under D or E. If this spoon were made of gold, but of a smaller size, or of hammered platina, it would be more convenient.

19. This is one of the supports of the matters under examination; but a piece of charcoal cut in a form almost cubical, as represented in fig. 2. pl. II, is the most commonly used in many assays. Particles of ores that are very small and light are easily

carried

carried off by the blast of air. To prevent this accident, a small cavity is to be hollowed in the charcoal, in which, being partly protected by another smaller piece of charcoal over it, they may be exposed to the apex of the flame: and on some occasions two pieces of charcoal are tied together with a binding-wire, that is packed up in the box near the hammer; and having made two hollows near the edges, a hard reducible substance may be there exposed to the greatest heat of the apex of the flame, as if it were in a reverberatory furnace. See § 18, p. 937, of the preceeding Treatise of Mr. Engeström.

20. The phial marked B contains crystalized borax, already described Sect. 182. When exposed to the flame upon the charcoal; at first it becomes opaque, white, and wonderfully intumescent; throws out branches and various protuberances: but when the water is expelled, it is easily collected into a mass, which, when well fused, yields a colourless bead, which retains its transparency even after cooling: see, however, note [1], p. 18. If calcined borax be employed, the clear sphærule is more speedily obtained. This is a neutral salt, and consists of mineral alkali partially saturated with a peculiar acid, known by the name of *Sedative Salt* (Sect. 165): each of its principles is separately fusible, and each dissolves a great number of other matters.

The habits of these salts, when exposed to fire, being once known, it will be easy to understand

understand the differences occasioned by different additions.

21. G is a small link of hard steel, to try the hardness or softness of mineral substances; and also to strike fire for lighting the candle, when required.

22. K denotes two pieces of black flint, to serve as a touch-stone: for being rubbed with any metal; if it be gold, the marks will not be corroded by *aqua fortis*; and also to strike fire, when necessary, with the link G.

23. I is an artificial load-stone, properly armed with iron for the better preservation of its attractive power. It serves to discover the ferruginous particles of any ore after it has been roasted, and powdered on the little square of steel N, within the ring H, Plate I, as mentioned N^o 13.

24. L is a triple magnifier, which, differently combined, produces 7 magnifying powers, the better to distinguish the structure and metallic parts of ores, and the minute particles of native gold, whenever they contain that metal.

25. R is a pair of tongs for the easy handling the small pieces to be tried or examined; and to turn or take out from the melted fluxes the small buttons, or reguline products of the processes when hot.

26 S is a file, to try the hardness of stones and crystals, &c. This is put under the hammer E or elsewhere.

27. There are also put in the empty spaces, under the instruments, some pieces of dry aga-

rice or tinder, and small bits or splinters of wood, tipped with brimstone, to serve as matches for lighting the candle, and various other little articles of use in these experiments.

2d. THE HUMID LABORATORY, viz.

For performing Experiments in the *Humid Way*.

28. The case of this Laboratory is of the same form and dimensions as that of the *Dry Laboratory*, the depth only excepted, which is double, in order that the phials may stand upright, without being exposed to shake off their stoples. It has been thought quite unnecessary to add a plate engraved with the figure of this Laboratory, since every one knows well what must be the form of such a collection of phials put together. They contain the principal *acids*, *tests*, *precipitants*, and *re-agents*, both for examining mineral bodies by the *humid way*, and for analysing the various kinds of mineral waters. Those with *acids* and *corrosive solutions* have not only ground stoples; but also an external cap to each, ground over the stople, and secured downwards by a bit of wax between both, in order to confine the corrosive and volatil fluids within. But those which contain mild fluid liquors have not such external caps: and those with dry inoffensive substances are only stopped with cork.

29. Besides these phials, there are two smaller cylindrical ones, which serve to exhibit the changes of colour produced by some of the
re-agents

re-agents in these analytical assays. There are also 2 or 3 small matraffes, to hold the substances with their solvents over the fire; a small glass funnel, for pouring the fluids; a little porcelane mortar, with its pestle; one or two crucibles of the same substance; a small wooden trough, to wash the ground ores; some glass sticks to stir up the fluid mixtures; and finally, pieces of paper tinged *red*, *yellow*, and *blue*, by the tinctures of *Fernanbuc wood* (commonly called *Brasil wood*) *Turmeric*, and *Lakmus*, thickened with a little starch.

30. The following list contains the names of the various *fluid tests* and *re-agents* that are necessary for these assays; and each phial is noted with the same ordinal number of the list, being distinctly cut with a point of a diamond on the outside surface of the phial. But their whole number being too large to be all contained in a small box, every one may give the preference to those he likes the best. They are the following :

- | | |
|---|---|
| 1. Concentrated <i>vitriolic acid</i> , whose specific gravity may be expressed in the outside. | 2. <i>Nitrous acid</i> , purified by the nitrous solution of silver. |
| 3. Concentrated <i>marine acid</i> , with its specific gravity. | 4. <i>Marine acid</i> dephlogisticated. |
| 5. <i>Aqua Regia</i> for gold, viz. 2 Nit. and 1 Marine. | 6. <i>Aqua Regia</i> for Platina, viz. half marine and half nitrous acid. |

7. *Nitrous*

- | | |
|---|---|
| 7. <i>Nitrous solution of silver.</i> | 8. Nitrous solution of mercury, made in the cold. |
| 9. Muriatic solution of Barytes. | 10. Nitrous solution of <i>Lime</i> . |
| 11. Muriatic solution of <i>Lime</i> . | 12. <i>Mercury</i> in its metallic state. |
| 13. Corrosive sublimate of <i>Mercury</i> . | 14. White <i>arsenic</i> . |
| 15. Nitrous solution of <i>silver</i> . | 16. Nitrous solution of copper. |
| 17. Acid of Sugar. | 18. <i>Liquor probatorius vini</i> . |
| 19. <i>Hepar Sulphuris</i> . | 20. Oil of tartar <i>per deliquium</i> . |
| 21. Salt of <i>Tartar</i> . | 22. <i>Caustic vegetable alkali</i> . |
| 23. <i>Pearl Ashes</i> . | 24. Soap-makers <i>Ley</i> . |
| 25. Common salt. | 26. Vitriolated <i>argilla (alum.)</i> |
| 27. Vitriol of iron [Copperas.] | 28. Nitrous solution of <i>silver</i> . |
| 29. Acetous solution of lead. | 30. Acetous solution of Barytes. |
| 31. Phlogisticated alkali by the Prussian blue. | 32. Lime-water. |
| 33. Lime-water phlogisticated by the Prussian blue. | 34. <i>Caustic volatil alkali</i> . |
| 35. Mild volatil alkali (dry.) | 36 Rectified spirit (alcohol). |
| 37. <i>Æther</i> . | 38. Spirituous tincture of galls. |

N. B.

N. B. *There are some other TESTS to be mentioned in the Note [*].*

31. The method of applying the above tests of acids and re-agents may be seen in Bergman's *Treatises of the Analysis of Waters*, and of assaying by the *humid way*; in Kirwan's *Elements of Mineralogy*, in the *Elements of Chemistry* of Dijon, in the *Memoirs* of the same Academy, in Fourcroy's *Lectures of Chemistry*, &c.

3d. DESCRIPTION OF THE LAMP-FURNACE.

For Experiments, by the Humid and Dry Way, represented in Plate the Second.

32. This very curious and useful tho' small apparatus, is an improvement of that which was contrived by Mr. de Morveau, in consequence of the information he received from his friend, the President de Virly, who saw at Upsal how advantageously the late eminent Professor Bergman availed himself of this convenience for many analytical processes in miniature, by the use of very small glass vessels, about one inch diameter, and other implements of pro-

[*] The following *Tests* are very fit also for these assays, viz. 39. Spirituous solution of soap; 40. Sirup of violets; 41. Tincture of Litmus (*Lakmus* in Swedish); 42. Tincture of Brasil wood; 43. Tincture of turmeric (*terra emerita*); 44. Oil of olives; 45. Oil of Linseed; 46. Oil of Turpentine; 47. Essential salt of wild-sorrel (*acetosella* vel *Oxalidis*); 48. *Hepar Sulphuris*; 49. Sugar of Lead; 50. Solution of Alum.

portional size, for performing various chemical operations. See the Dijon Memoirs for 1783, part 1, p. 171.

33. There can be no doubt but that whenever these processes are properly conducted, though in miniature, the lamp-furnace will prove amply sufficient to perform, in a few minutes, and with very little expence, the various *solutions*, *digestions*, and *distillations*, which otherwise would require large *vessels*, *stills*, *retorts*, *reverberatory furnaces*, &c. to ascertain the component parts of natural bodies, though it is not always sufficient to ascertain their respective quantities. In this last case operations must be performed in great laboratories, and on a large scale, at a considerable expence. But the substances are sometimes too valuable, as for instance, when precious stones are examined, and of course the last way never can be attempted in such cases.

34. These small processes have likewise another advantage before noticed which cannot be obtained in works at large. It consists in one's being able to observe the gradual progress of each operation, of easily retarding, or urging it, as it may require; and of ascertaining at pleasure each step of every experiment, together with the phenomena attending the same.

35. The lamp-furnace is mounted in a small parallelogram of mahogany, about 6 inches long and 4 wide, marked *fig. 5*, in plate 2. This is kept steady over the edge of a common table, by means of the metallic clamp *ww*, which

which is fastened by the screw *x*. The pillar *rs* is screwed in a vertical position on the plate *s*, being about 10 inches high; the other is screwed to the opposite corner, marked *p k*, and is only $7\frac{1}{2}$ inches long; both are composed of two halves, that screw at *tt*, to be easily packed up with all the implements in a case covered with black fish-skin, and lined with green velvet, like the other laboratory already described.

36. The lamp *k* fig. 3 is supported on the plate *f*, which has a ring *l* that runs in the column *p k* and may be fixed by its screw *l* at the required height. This lamp has 3 small pipes of different sizes to receive as many wicks of different thickness, and to be filled with spirit of wine. By a similar method, a piece of charcoal is mounted and supported by the pliers, or little forceps screwed to the arm at fig. 1, which has all the motions requisite for being fixed by means of proper screws, at a proper distance from the flame of the wick *b*. The blow-pipe fig. 4. is, by a similar mechanism, mounted on the smaller column *pq*, at such a distance as to blow the flame *bi* to the piece of ore *m*, which is upon the charcoal *gf*.

36. Every thing being disposed in this manner, the operator blows through the mouth-piece of the blow-pipe, fig. 4, and remains with his hands free to make the changes and alterations he may think proper.

N. B. The large round cavity *e* in the middle of the parallelogram, fig. 5, is to receive

S s s

the

the lamp *k* fig. 3, when all the implements are packed up in their case of black fish-skin; and the cover of the lamp is represented by fig. 13.

37. But if the operator has the double bellows, fig. 14 and 15, he fixes them to the table by the brass clamp *y*. He then unscrews the blow-pipe at *zz*: joins the mouth *m* of the flexible tube to the hemisphere *zz*, passing each orifice, through the leather tub fig. 12, and tying both ends with a waxed thin pack-thread. If he works with his foot on the pedal, the string of which is seen hanging from the end of the bellows, fig. 15, (and is always up, on account of the weight *e*) then the air is absorbed by the bellows fig. 15, from whence it is propelled by the motion of the foot on the pedal, to the bellow fig. 14, whose constant weight *r* drives it out through the flexible pipe fig. 11: it of course enters the curved part *zzi* of the blow-pipe, and drives the flame on the piece *m* of the ore, that is to be examined upon the charcoal.

N. B. 1. This double bellows is packed up by itself in a mahogany case, about 9 inches long, 6 $\frac{1}{2}$ wide, and about 3 $\frac{1}{4}$ deep, outside measure.

N. B. 2. The last blowing bellows, fig. 14, has an inside valve, which opens, when the upper surface of it is at its greatest height: in order to let the superfluous air escape out, as it would otherwise issue with great velocity out of the tube fig. 11. and spoil the operation.

38. If

38. If the operator chuses to apply the *vital* or *dephlogificated* air in his process, let him fill the glass-jar *b*. *fig.* 17, with this air; and put it within the tub marked by *a b z c*, filled with water, fastening the neck of the jar within by a cross-board *ed*, which has a hole in it for that purpose; then introducing the two ends of the flexible hollow tube (*fig.* 16) both to the mouth of the jar, and to the hole of the bellows, *fig.* 15; he opens the hole *m* of the jar, that was stopped with the stopple *n*; the column of the water passes in through *m* and forces up the *vital* air, which enters the bellows, and of course, by the alternative motion of the pedal, passes through the end of the blow-pipe, to urge the flame upon the piece of ore *m fig.* 2. on the charcoal *g* [*a*].

[*a*] But the *dephlogificated* air may be also received at the same time, that it is produced, by tying the pipe, *fig.* 16. to the mouth an earthen retort, or of such a porcelain ware as that from Mr. Wedgwood's manufactory, or even of a glass retort well-coated, according to the method of Mr. Willis, described in the Transactions of the Society of Arts, vol. V. p. 96. This last consists in dissolving 2 ounces of borax in a pint of boiling water, and adding to the solution as much slacked lime as necessary to form a thin paste: this glass retort is to be covered all over with it, by means of a painter's brush, and then suffered to dry. It must then be covered with a thin paste made of *linseed oil* and *slacked lime*, except the neck that enters into the receiver. In two or three days it will dry of itself; and the retort will then bear the greatest fire, without cracking. Two ounces of good nitre, being urged in the retort, by a good fire on a chafing-dish, will afford about 7 or 800 ounce-measures of dephlogificated air. See Priestley's Experiments on air, vol. III, (or VI.) of his Philos. Works, p. 295.

39. To make any other kind of chemical assays, the forceps of *fig. 2*, which supports the charcoal, is taken off, by unscrewing the screw *b*; the blow-pipe is also taken off, by loosening the screw *n*; the hoop *fig. 8*, is put in its place, where the metallic basin of *fig. 19*, is put filled with sand: the piece of *fig. 9*, is set on the other pillar *rr fig. 1*, to hold the matrafs, *fig. 18*, upright or the receiver *fig. 21*, &c.

40. In the same manner the retort *fig. 10*, may be put in the sand-bath instead of the matrafs, with its receiver *fig. 21*, which may be supported on a bit of cork or wood hollowed to its figure, and held by the pycners, instead of the charcoal *fig. 2*.

41. But if the operation is to be made in the naked fire, the neck of the retort *fig. 10*, being luted to the receiver, or balloon *fig. 21*, may be hanged by a little chain with its ring, over the flame, being suspended from the piece of *fig. 8* or *9*, screwed to either of the pillars as may be most convenient. Otherwise the receiver, *fig. 21*, may be supported by the round hoop of brass, *fig. 9* or *8* screwed at a proper height to the pillar, *fig. 1*, tying round it some packthread, to defend the glass from the contact with the metallic support.

42. The piece of *fig. 6* may be screwed by its collar and screw *ef* to any of the pillars; carrying with it the retort and its receiver, at proper distances, higher or nearer to the lamp, according as the flame is more or less violent.

43. It easily may be conceived that these implements afford all sorts of conveniences for making any kind of small operations and assays in miniature, provided the operator pays a proper attention to the disposition requisite for each process or operation.

44. Every glass retort, receiver, matraſs, baſin, ſmall funnels, &c. was made by the lamp-workers, that blow beads, thermometers, and other ſmall glaſs instruments. N. B. The little funnels and ſyphons, to take off the waſhings from the ſubſtance that has boiled over the fire, were not engraved in *plate the ſecond*, to avoid crowding it, and embarraſſing the attention of the reader. Their figures are, however, ſo well known, that this omiſſion cannot produce any embarraſſment to a perſon of the leaſt ingenuity.

45. It is directed at N^o 36, that the lamp *k. fig. 3.* is to be filled with ſpirit of wine, becauſe it gives no diſagreeable ſmell, and does not produce any fuliginous and diſagreeable cruſt on the veſſels as oil does; moreover, the ſpirit gives a dry flame, without ſmoke, and ſtronger than oil; beſides the ſpots and diſagreeable conſequences this laſt cauſes, if ſplit, &c. Mr. de Morveau adds, that the expence of ſpirit is quite inconfiderable, and that he performed in 8 or 10 minutes, with this apparatus, various diſſolutions, evaporations, and other proceſſes, which otherwiſe would have taken more than 3 hours, with the expence only of two or three halfpence for

the spirit of wine, whilst the fuel of charcoal would have cost near 10 or 11 pence.

46. But a very important circumstance is, as Morveau observes likewise, that many philosophers do not apply themselves to chemical operations, for want of opportunity of having a laboratory to perform them, it requiring a proper room, and suitable expences of many large furnaces, retorts, crucibles, and numerous other implements, &c. whilst these miniature laboratories may in great measure afford the same advantages, at least to that degree of satisfaction sufficient to ascertain the contents and products of any substance that is subjected to trial; for with this simple apparatus a man of some abilities may, without any embarrassment, in a very short time, and with little expence, perform such distillations as require a reverberatory furnace; all sorts of processes, digestions, and evaporations, which require a regular and heat; he may vary his experiments or trials, and multiply them to a great number of various performances, draw up his conclusions, and reason upon them, without loss of time, without the hindrance of long preparations to work at large. And even when such large works are to be performed, he may observe beforehand various phenomena of some substances, which being known in time, would otherwise impede the processes at large, or make them fail absolutely; and all this without the risk of a considerable loss, and without exposing himself to a great fire, &c.

47. The results will be rarely, if ever, equivocal, especially if the operator is a man possessed of natural sagacity, and well acquainted with the general properties of the natural substances already known. If he directs his attention to the phænomena that happen in his experiments; and endeavours to use the proper means to obtain the knowledge he aims at, in order to destroy common prejudices, or to confirm those ideas and judgements of the objects he is to try and examine with his own eyes: in such a case he may depend upon it that his labours, in the corner of his study or cabinet, will never be, without producing some knowledge; since they will at least serve to direct him in those operations at large, which may be required to complete the proposed object, &c. *The Editor.*

A P P E N D I X II.

Containing various particulars of useful information to Mineralogical Enquirers,

1. *The Analysis of Earths and Stones by Kirwan.*

§ 1. The best general solvent for stones or earths seem to be *Aqua Regia*, composed of two parts *nitrous*, and one of the *marine acid*.

S s s 4

If

If the stone or earth effervesces strongly with acids, no other preparation is requisite than a separation of such parts as are visibly heterogeneous, and pulverization; the solution is then easily performed in a digesting heat, if requisite. The undissolved residuum, if purely siliceous, will melt into a transparent glass with half its weight of *mineral alkali*; if not, it is still compounded, and its soluble parts will yield to a reiterated digestion.

§. 2. If the stone does not effervesce, or easily dissolve in acids, after pulverization and digestion, but leaves an insoluble residuum evidently compounded, or but slightly altered, it will require to be pulverized and mixed with twice or thrice its weight of *mineral alkali*, and to be exposed to a low red heat for one or two hours. Miça requires a mixture of four times its weight of *mineral alkali*; after which it is to be separated from the alkali by lixiviation and filtration, washing it with distilled water until the water is absolutely tasteless and precipitates no metallic solution.

§. 3. The powdered stone, thus edulcorated, is to be dried by heating it to redness, and then weighed, and 100 grains taken for subsequent experiments. It were better if still more were used, but the analysis would be more expensive.

§ 4. The powder is next to be digested in 8 or 10 times its weight of *aqua regia*, in a boiling heat in a retort, to which a receiver is luted, and the digestion reiterated as long as
any

any thing appears to be dissolved by fresh portions of the acid. Mica was found to require 50 times its weight of *aqua regia* before it was entirely decomposed, as the acid is so volatile as very soon to distill over. Oil of vitriol has the advantage of bearing a greater heat, dissolving baroselenite, and of acting more powerfully on argill than *aqua regia*; but a large retort must be used, for often towards the end it puffs and throws up the earth or stone, and carries it into the receiver; besides, it does not sufficiently act on calces of iron, if these be much dephlogisticated. *Spirit of Nitre* affects them still less: hence I often use oil of vitriol first, then what has been dissolved I precipitate by a mild alkali; and re-dissolve the precipitate in *aqua regia*. A perfect solution being thus effected, the residuum is to be well washed, and the washings added to the solution: the residuum, well dried and weighed, gives the weight of siliceous earth in the compound.

§ 5. The solution is next to be examined; which we will suppose to contain the four soluble earths, *calcareous*, *ponderous*, *magnehan*, and *argillaceous*, and also a *calx of iron*; it always contains an excess of acid, of which it is in great measure deprived for a considerable time, as both acids are very volatile: and indeed, of the *marine*, none remains but what is combined with the calx of iron, as the nitrous chases it from the earths. By getting rid of this excess of acid, less alkali will be required.

for the preceding precipitation, and less aerial acid set loose which would retain much of the precipitate by re-dissolving it; the solution should then be evaporated to about half a pint.

§ 6. The solution being thus prepared, it is usual to precipitate the calx of iron from it by the *Prussian alkali*; but to this method there are two objections: 1st, That the *ponderous earth*, if any, would also be precipitated and confounded in the *Prussian blue*: and 2d, That this precipitation, besides being exceeding slow, seldom fails of leaving some iron still in the solution, as the excess of the *Prussian alkali* which must necessarily be added, to be certain that all the iron is precipitated, never fails to re-dissolve a portion of the *Prussian blue* which thus remains in the liquor, and cannot be got rid of. Hence the best method is as follows: first, prepare the *Prussian alkali* after the manner of Mr. *Bergman*, by digesting and boiling a pure alkaline solution over *Prussian blue*, until the alkali no longer effervesces with acids, nor precipitates a solution of nitrous selenite, or any other earth, except the barytes. I even make it a little stronger; for if it be barely saturated with the tinging matter, it soon spoils and precipitates other earths, the tinging matter evaporating. Next let it be examined how much of this alkali is necessary to precipitate one grain of *iron* from its solution in dilute *vitriolic* or *marine* acid, and mark this on the label of the bottle

bottle that contains the alkali. Now we come to the application

§ 7. The solution of the earths being weighed, take 100 grains of it, and on these gradually pour the Prussian alkali (a portion of which is also previously weighed) until all the *iron*, or *ponderous earth* and *iron*, is precipitated; the weight of the alkali used, gives that of the *iron* contained in 100 grains of the solution; and the quantity contained in 100 grains of the solution gives that contained in the whole solution by the rule of proportion, from which the ponderous earth, if any be found in subsequent experiments, is to be deducted.

§ 8. The quantity of iron being thus found, the remainder of the solution is to be precipitated by aerated mineral alkali, and then boiled for half an hour, to expel as much as possible of the fixed air; by this means the whole of its contents are precipitated, and nothing remains in solution, but cubic nitre and a little common salt; when the precipitate has settled after one or two days rest, the liquor is to be poured off, and the last portions taken up with a glass syringe. Distilled water is then to be added to the precipitate and boiled over it, and afterwards poured off, and taken up until it comes off tasteless.

§ 9. The precipitate being sufficiently dried, is to be re-dissolved in nitrous acid twice, and evaporated to dryness, then calcined for one hour in a white heat, and lastly treated with about six or eight times its weight of distilled vinegar,

vinegar, in a heat of about 60 degrees, for one or two hours; by this means the *ponderous*, *calcareous*, and *magnesian* earths will be extracted and separated from the argill and calx of iron, which will remain undissolved.

§ 10. Of this acetous solution 100 grains should be taken and examined with the Prussian alkali: if any part be precipitated, it is ponderous earth, and by heating it to redness its weight may be known: or still better by a previous experiment, determining the quantity requisite to precipitate one grain of acetous baroselenites, and by the rule of proportion the quantity of it in the whole solution may be found.

§ 11. The remainder of the acetous solution is to be evaporated to dryness, and heated white in a clean polished iron crucible for two hours, then weighed and thrown into hot distilled water; the calcareous earth (if any) will be dissolved in a sufficient quantity of this water, of which an ounce can scarcely dissolve one grain, so that frequent affusions of hot water may be requisite; the magnesia will remain undissolved, and is to be dried and weighed; its weight gives that of the pure calcareous earth, from which that of the ponderous (if any) is to be deducted; the lime water may also be precipitated by an aerated alkali.

§ 12. Lastly the argill and calx of iron, which remained undissolved by the acetous acid, are to be heated slightly, to prevent their
cohering

cohering and reiteratedly boiled in dephlogisticated nitrous acid to dryness, and finally dissolved in that acid, which will then take up only the argill, which may be precipitated, dried, and weighed; though indeed this troublesome operation may be unnecessary, as the weight of the martial part being known by the experiment with the Prussian alkali, that of the argill is known of course, when only the two remain. This is even better, as the calx always increases in weight by these operations.

§ 13. Besides this general method, some others may be used in particular cases. Thus to discover a small proportion of argill, or magnesia, in a solution of a large quantity of calcareous earth, caustic volatile alkali may be applied, which will precipitate the argill or magnesia, if any be, but not the calcareous earth. Distilled vinegar, applied to the precipitate, will discover whether it be argill or magnesia.

§ 14. 2dly, *A minute portion of calcareous or ponderous earth, in a solution of argill or magnesia,* may be discovered by the vitriolic acid, which precipitates the calcareous and ponderous; the solution should be dilute, else the argill also would be precipitated. If there be not an excess of acid, the saccharine acid is still a nicer test of calcareous earth. 100 grains of gypsum contains about 32 of calcareous earth; 100 grains of baroselenite contains 84 of ponderous earth; 100 grains of saccharine selenite contains

tains 45 of calcareous earth ; the insolubility of baroselenite in 500 times its weight of boiling water sufficiently distinguishes it. From these *data* the quantities are easily investigated.

§ 15. 3dly, *A minute proportion of argill in a large quantity of magnesia* may be discovered either by precipitating the whole and treating it with distilled vinegar, or by heating the solution nearly to ebullition, and adding more aerated magnesia until the solution is perfectly neutral, which it never is when argill is contained in it, as this requires an excess of acid to keep it in solution. By this means the argill is precipitated in the state of embryo alum which contains about half its weight of argill (or for greater exactness it may be decomposed by boiling it in volatil alkali). After the precipitation, the solution should be largely diluted, as the Epsom salt, which remained in solution while hot, would precipitate when cold, and mix with the embryo alum.

§ 16. 4thly, *A minute portion of magnesia in a large quantity of argill* is best separated by precipitating the whole, and treating the precipitate with distilled vinegar.

§ 17. Lastly, *Calcareous earth and Barytes* are separated either by precipitating the barytes by the Prussian alkali, or the calcareous by a caustic fixed alkali, or by precipitating both with the vitriolic acid, and evaporating the solution to a small compass, pouring off the liquor, and treating the dried precipitate with

500 times its weight of boiling water ; what remains undissolved is baroselenite.

II. *Description of a new Instrument for finding specific gravities, by Nicholson.*

Since mineralogists often want to know the specific gravity of various *stones*, and other *ores*, as well as of *fluid acids* and other liquors ; a description of a new instrument of this kind may be acceptable in this place, as it is very easy and portable. It was invented by Mr. W. Nicholson, and is inserted in the second vol. of *Memoirs*, published by the *Philosophical Society of Manchester*, in 1785, from whence the following extract may be sufficient to form an idea of its advantages.

2. This instrument is represented by *fig. 23*, Plate 2, and it consists in a thin hollow ball A. of copper, of the size of a common hen's egg, with a small basin *c.* like a funnel, supported by a thin wire *db.* on the top, and a small basin *gb.* at the bottom, which must be so heavy, that on loading the upper one *c.* with 1000 grains (or half grains), when the instrument is immersed in distilled water, its surface be exactly at *cc.* [*g*].

3. Suppose

(*g*) This ball must be turned in the lathe very thin, and be tight against water and air. On the top is a little shoulder *b* with such a hole, as to receive pretty tight the body of

3. Suppose you want to know the specific gravity of the body x , which must be of course less than 1000 *half grains*. On putting it in the upper basin e , so many units, or half grains, must be added in the same basin, as to make it sink, until the surface of the water comes to the white circle of the stem. It is evident that the weight of x is equal to the remaining unities, after the additional weight in the basin e is subtracted from 1000; thus, for example, if there were added to e 280 unities; in this case the weight of x is 720: for $+ 1000 - 280 = 720$ [b].

4. Now

a common sewing needle whose point and eye have been broken off; this is to have a visible mark in the middle, for which purpose it is first rendered blue by heat; and by rubbing it with a thin plate of brass crossways, wetted with oil and fine emery, a small circle of the white metal will be there sensibly formed round it.

[b] *N. B.* 1. The water must be the same in every experiment, and must have the same temperature; the 60 degree of Fahrenheit, is the most convenient, as it is commonly found in a temperate room. A small thermometer therefore must be always provided for the use of the instrument: 2. And if the instrument itself requires a greater or less number of grains to sink it to the mark at any given temperature; it will serve at any time to shew whether the density of the water is the same of that of distilled water, &c. 3. Great care must also be taken that no bubble of air be sticking to the body x , or to the under basin during the experiment, or else the result will be erroneous. 4. The handling of every part must be made by a pair of dry tongs, such as those of fig. 7. 5. Finally, if the water cannot be had distilled, nor even rain water, which is nearly the same; then the body x that is kept with the instrument must be examined in this water, and a new body being also examined,

4. Now let x be put in the lower basin gh , leaving the other unities as before in the basin e ; then add as many of the same unities to e , until the surface of the water be again at cc . This additional number shews exactly the quantity of water that is displaced by the body x . Suppose it to be 60 unities: divide now the whole weight ($=720$) by this known bulk of water equal to it, viz. 60, and the specific gravity of x will be shown by the quotient; viz. $\frac{720}{60} = 12$: which denotes, that the body x is 12 times heavier than an equal bulk of distilled water.

5. As for ascertaining the specific gravities of *acids*, or other *fluid matters*, the same method, already explained in the Notes to pages 612 and 613, may be equally applied to this new instrument.

6. Or else, take a very small glass phial, with a ground stopple, and ascertain, when filled with water, its specific gravity by the above method; afterwards fill it exactly with the *acid*, or *fluid substance*, and determine by the same method the specific gravity of both; deduct that of the phial alone, from the second lastly ascertained; and the remainder will be the specific gravity of the *acid* or *fluid* you tried the last.

examined, the respective specific gravities forming a compound with the weight of each body, a proportional result may be found to determine the true specific gravity of the new body relatively to distilled water. The observations in this note apply universally to all hydrostatical experiments made with any instrument whatever.

III. *An easy and very accurate Method of making ORIGINAL WEIGHTS. By the EDITOR.*

7. A very great difficulty, for the above operations of finding specific gravities, consists in having a very exact set of weights. I have discovered a new method, which I published seven years ago in the *Journal de Physique*, for January 1781, page 43. It is the easiest, the cheapest, and the most exact, of any that ever was practised before; notwithstanding which, I often hear repeated complaints of experimental operators, who still adhere to the old and tedious method, without taking notice of the new one. This last consists on the following particulars.

8. *First*, Let a pair of scales with a very nice beam be provided, within a lanthorn, with glass panes on every side, having two small lateral doors that may be open, facing each of the scales. These are the only openings to be used, the front one being always shut during the operations, on account of the breath of the operator, which otherwise would disturb the balances. As to the qualities of the beam, the essential one is; that it be constantly true, and sensible to the smallest weight, every time it is tried; for there are many false or unskillfully constructed beams, that often vary in giving the equipoise of the very same things. But as to the length of the arms, from the point
of

of suspension, it is no matter whether they are accurately equal or not.

Each scale must have a loose small basin very light, to convey the things and weights in every operation.

9. *Secondly*, Prepare a good quantity of equal *unities*, for which a good method will be given by and by. Take a piece of *tinsel*, which is the thinnest plate of *latten* (or *latten foil*, as Watson calls it), such as the tassel and button-masters employ in their work, but this must not be varnished any ways; which may be easily known by wetting it with water, for it will then dilute the coloured substance of the isinglass with which it was varnished. If so, let it lie in hot water about twenty minutes; then wash and wipe it. *4thly*, Cut out twelve or more triangular pieces of the tinsel, beginning with a very small one about the $\frac{1}{8}$ part of an inch, and increasing the others little by little, till the largest is the size of an inch; and fold one of the corners of each upwards, that it may easily be taken up with the tongs of Fig. 7, Plate II. *5thly*, You should be provided with a set of very small punchers of steel, containing the ten numerical figures, from 0 to 9 inclusively. These are sold ready made at the tool-shops, and cost only two or three shillings. *6thly*, Stamp your smaller triangle with No. 1. the second in size with No. 2. and so on. This being done, cut a small parallelogram a little heavier than your greater triangle, which you will mark with No. 13 or 15, and

T t t 2

cut

cut others till they are the size of an inch, taking care to bend one corner of each.

10. Take afterwards a piece of the common latten sheet, which is considerably thicker than the tinsel, and do the same as before, beginning with a triangle a little heavier than the biggest parallelogram of tinsel, and marking it with the following numbers of 24 or 30, and so on as before. Afterwards do the same with brass plate whose thickness may be afterwards increased as far as your beam will be able to bear without bending or spoiling its axis. Then shut up each set of weights separately in small cases or boxes, and stamp upon the outside of each the two extreme numbers (the highest and the lowest) of the pieces or weights there contained, in order to know afterwards in what box are the weights you may want.

11. Take now a very thin wire of gilt silver or metal, such as the finest employed by the wire-drawers, before it be flattened in the mill, for covering the silk threads; wind it up very closely upon two wires as thick as large pins, viz. about $\frac{1}{8}$ of an inch thick; then cut the whole cover of thin wire lengthways, with the point of a sharp penknife, running it between the two thick wires, and collect all the small oval rings to serve as so many *unities*, which you may keep in a small box by themselves; and the same must be done with each dozen of the triangles and parallelograms, according to their numeros, the first and last of which should be marked on the outside, to find it easily

easily when necessary, as was already observed in the last article.

12. *N.B.* You must form your unities of such wire, that each be very sensibly felt by your own scales; otherwise your labour would be worth nothing; for you cannot go farther than the least quantity of weight that your scales are able to indicate.

Now, as to the practical method of making the nicest operations with weights, it consists in making use only of the right-hand basin, both for the things to be examined, and for the weights; employing the left-hand scale only for counterpoising each weight as follows.

13. Make your scales very even, by putting some bits of brass or wire on the left-hand one, both having one small movable basin as above-said. When the equilibrium is perfect, take with the tongs (fig. 7.) the right-hand basin; put therein your smallest triangle No. 1, and putting it again in the same scale, counterpoise it in the left-hand with any small bits of metal.

14. *N.B.* Try whether it is right, by adding one *unity* more, and taking off another afterwards: observing whether the beam moves on each side. This proof is the most essential of all. After this, take out the right-hand basin, and the triangle: put in as many *rings* or unities (No. 11.) as will counterpoise the other scale on the left-hand; and try by the above method of *adding* and *subtracting* one unity, that it is right.
After-

Afterwards the same must be observed with each weight. Form then a list of your weights in a sheet of paper divided into three columns; the first on the left-hand intitled *Pieces*; the second *Quantity*; and the third *Accuracy*. Fill up the first column with a continued series of numbers from 1 to 100, or to such other number as you please. Then write facing each number the total of *unities* answering to each piece marked with the same; and in the third column write the *unity*, which being added or subtracted, makes the balance turn one way or other. By this last column it will appear how nice your weights are, and how delicate are your balances [i].

15. By this method you may use as many sets of weights as to come to hundreds and more pounds, with this particular advantage, which no one else ever obtained before, *viz.* of having a thorough conviction that each of your ounces or pounds cannot be deficient within or beyond one of your unities, if to such an accuracy you have carried your performance [k].

16.

[i] You are to employ, in each operation, the same pieces whose weight is already ascertained, adding only three or four of your unities, mentioned No. 11; and by so doing you will have the certainty that each is exact to a less error than one of the said unities, which is no more than $\frac{1}{1000}$ or $\frac{1}{300}$ of a grain weight.

[k] This proposition is self-evident, and of course does not require any demonstration. But it is proper to observe, to such as are unacquainted with the subject, that very large weights cannot be ascertained totally, with such a nicety as is here mentioned. The only obstacle, which indeed is insuperable,

16. Lastly, to know the relative weight of the Troy kind, get one of the most authentic *penny-weights* from the Mint in the Tower, or from the King's Assayer; weigh it with your weights, and you will immediately know how many of your unities make a penny-weight of England, or a *gros* of France, and so on of any other country whatever; so that by a simple calculation you will possess an original and universal scale for all kinds of weights.

THE EDITOR.

N. B. *All the above instruments, viz. the two Pocket Laboratories, the Lamp-furnace, the new instrument for specific gravities, and the sets of new weights, are sold at moderate prices, by William Brown, Bookseller, at the corner of Effex-street, in the Strand, near Temple-Bar, London.*

superable, consists in this, *viz.* that among all the known substances to which the human power can have recourse, there are none so hard and unalterable as to form a beam, whose axis or points of suspension, when loaded with the pressure of *twice twelve ounces*, (two pounds weight,) shall not be so blunted or altered as to be incapable of yielding to the gravitating power of $\frac{1}{8000}$ of a grain. From whence it is equally self-evident, that no weight whatever can be ascertained at once to a much greater accuracy than to the least small quantity, which being added or subtracted, will cause some sensible difference in its perfect equilibrium.

THE END.



A N

ALPHABETICAL TABLE

OF THE

C O N T E N T S.

The Numbers indicate the Pages; the three Letters *a. b. c.* mean the *top*, *middle*, and *bottom* of each; and *n* means to be in the *Notes*.

A.

- A* *Celdama terra*, 20. *b. n.*
Achates, 186. *b. calcedo-*
nifans, 187. *b.*
Achates Islandicus, 917. *a.*
 Acid Salts, their properties,
 276. *a.*
 ———, their mutual con-
 version, by Count de Sa-
 luges, 286. *b.* 294. *b. n.*
 Adamantine Spars. *See Ad-*
ditions to p. 133.
 Aerial acid, its properties,
 320. *a.*
 Aerated calx, 381.
 ——— iron, 406. *a.*
 ——— Magnesia, 388. *b.*
 ——— ponderous earth,
 383. *a.*
 ——— (mild) volatil alkali,
 374. *a.*
Æs corinthiacum, 785. *a.*
 Æther's inflammable vapour,
 447. *c. n.*
- Agaricus mineralis*, 20. *a.*
 Agate, 186. *b.*
Agstein, 460. *a.*
Alabandicus lapis, 154. *a.*
 Alabaster, 34. *b.* — Micace-
 ous, 35. *a.*
Alabastrites, 35. *c.*
 Albarese, 77. *c.*
Alfwarsten, 71. *b.*
 Alkaline earths, 19. *a.*
 ——— salts, 326. *a.*
 ——— vegetable, 329. *a.*
 ——— Mineral, 333. *a.*
 Both *vegetable* and *mineral*
 alkalies exist in vegetable
 substances, before incine-
 ration, 344. *c. n.*
 Alkali (mineral) from the
 Sea-salt, 336. *c. n.*
Alkali (minerali) with Magne-
 sia, 420. *b.*
 ———, with succine-
 ous acid, 421. *a.*

U n d e r

Alkali

1018 TABLE OF CONTENTS.

- Alkali volatile 337. *a.*
Almandinus Ruby, 135. *b. n.*
Alumen (alum), 389. *a.*
 Its properties, 394. *b. n.*
 Observations on Allums, 394. *a.*
 Native Allum with Sulphur, 423. *a.*
 Aluminous vitriol of iron, 421. *c.*
 Alum, with vitriolated cobalt, 423. *c.*
Amandola marble, 81. *c.*
Amber, 421. *a.* Its properties, &c. 460. *a.*
Ambergris. Its properties, origin, &c. 457. *a.*
Ambra flava, 460. *a.*
Ambaix, (*Pierre de St.*) 83. *b.*
Amethyste, 151. *a.*
Amethyste root, or mother of it, 152. *a.*
Amethyste, 169. *b.*
Amethystizontai, 153. *b.*
Amintus, 114. *a.*
Ammoniac (salt native), 372. *c.*
Ammoniicum (*sa'*) *fixum*, 17—39. *a.*
Amygdalites, or *Amygdalides*, 884. *a.*
Analysis of earths and stones, how...? 999. *c.*
Antrodamas, 183. *b.*
Antimony, 790. *a.* Native, 793. *a.* Calciform, 795. *a.* Its varieties, 797. *n.* Mineralized, *ibid.* and 799. *a.*
 Red antimony ore, 798. *a.* Observations on it, 801. *a.* *Piua perpetua* of Antimony, i. e. that never lose their purgative power by passing through the organs of digestion, 803. *b. n.* It is often poisonous, 805. *b. n.*
Aphicnatron, or *Aphronitrum*, 368. *c.* 418. *a. n.*
Aqua marina, 145. *a.*
 Aisle land, observations on it, 53. *c.*
 The best compound, 55. *c. n.*
Argentum vivum, 577. *a.*
Argilla (common), *plastica*, 254. *c.* 941. *b. n.*
 The pure *Argilla* is the base of Allum, 282. *c. n.*
Argilla aerata, 231. *Intumescens*, 255. *c.*
Argilla ammoniac, viz. with volatil alkali (ammoniac of Argill), 399. *a.*
Argilla salita (*Mariate of Argilla*), 398. *b.*
 Argillaceous earth, 226. *a.* Its properties, *ibid.*
 Argillaceous fissile stones, 256. *c.*
Amenus (*Lapis*), 60. *c.*
 Asbestos, 113. *b.* Membranaceous, 114. *b.* *Sulzer montanum*, 115. *a.* Byfus, 115. *b.* Observations on Asbestos, 116. *b.* Cloth made of it, 117. *c. n.* Asbestos of 13 sorts analysed, 118.
 Ashdrawer, 154. *b.*
Aykby, 757. *a.*
Asphaltum, 471. *c.* 505. *b. n.*
 Attraction (polarity of) 429. *c. n.*
 Aventurine,

TABLE OF CONTENTS. 1019

Aventurine, 144. <i>b. n.</i>	Bismuth. (<i>Bismuthum</i>). Its
<i>Aurum fulminans</i> , 530. <i>b.</i>	properties, 757. <i>a.</i> 963. <i>c.</i>
<i>Aurum musivum</i> , 635. <i>a.</i>	<i>Nativum</i> , 759. <i>b.</i> Calciform,
	760. <i>b.</i> Mineralized, 761.
B.	<i>b.</i> <i>Ferro sulphurato</i> , 762.
Balance (new) for specif.	<i>c.</i> With Arsenic, 763. <i>b.</i>
gravities, 1007. <i>a.</i>	Observations on Bismuth,
Balass (rubi), 136. <i>a.</i>	764. <i>b.</i> Sympathetic ink
Baldwin's phosphorus, 17.	of it, 768. <i>b. n.</i> Gives no
<i>c. n.</i>	blue colour to glass, 769.
Ball-ore, 560. <i>b.</i>	<i>c. n.</i>
<i>Blatter ertz</i> , 565. <i>b.</i>	Bitumens (observations on)
Barbadoes-tar, 468. <i>a.</i>	503. <i>a.</i>
Baro-selenite, 80. <i>a.</i> 88. <i>a.</i>	Bituminous schistus, 479. <i>c.</i>
<i>Barote</i> , 84. <i>b.</i>	<i>Blabest</i> , 882. <i>b.</i>
Barytes. <i>See</i> Ponderous earth.	Black-amber, 473. <i>c.</i>
—— <i>acutata</i> , 87. <i>a.</i> 383. <i>a.</i>	Black-jack, 499. <i>b.</i> 779. <i>b. p.</i>
—— Muriatic, 382. <i>c.</i>	Black-lead. Its properties,
—— vitriolated, 382. <i>a.</i>	451. <i>a.</i> Its traces taken
Basalt, 207. <i>c. n.</i> Its forms,	off by the <i>Insian rubber</i> ,
<i>ibid.</i> Globulous, 913. <i>c.</i>	454. <i>c. n.</i> Drawing pen-
<i>n.</i> Of various colours,	cils how made of it? 454.
915. <i>c. n.</i> <i>Shorls</i> , <i>spars</i> ,	<i>c. n.</i> Its uses, 455. <i>c.</i>
<i>zeolithes</i> , <i>chrysolites</i> , &c. are	<i>Black-mock-lead</i> , 560. <i>c.</i>
found in them, 916. <i>b. n.</i>	Black wadd, 859. <i>b. n.</i>
<i>Bathensis (calx)</i> , 75. <i>b.</i> 20. <i>b.</i>	<i>Blank d'Espagn.</i> , 77. <i>b.</i>
Beads, transparent and opaque,	Blende. <i>See</i> Zink, 769. <i>b.</i>
18. <i>b. n.</i>	Its principal varieties, 778.
<i>Belesoon</i> , 455. <i>a.</i>	<i>b. n.</i> Phosphorescent, 781.
Bell-metal, 708. <i>c.</i>	<i>b. n.</i>
Bergman improved his sand,	<i>Bley</i> , 644. <i>a.</i> <i>Bly</i> , <i>ibid.</i>
55. <i>b.</i>	<i>Bleyglanz</i> , 561. <i>a.</i> 660. <i>c. n.</i>
<i>Bergbau</i> , 60. <i>a.</i>	<i>Bleyfchweif</i> , 661. <i>a.</i>
<i>Bergbartz</i> , 471. <i>c.</i>	Blow pipe (its use), 925. <i>a.</i>
<i>Bergmilch</i> , 20. <i>c. n.</i>	Its description, 929. <i>c.</i>
<i>Bergsch</i> , 467. <i>a.</i>	Calcination of ores by it,
<i>Bergtheer</i> , 468. <i>a.</i> 471. <i>c.</i>	952. <i>Pyrites aureus</i> can-
<i>Bergzunder</i> , 565. <i>b.</i>	not be tried by it, 953. <i>b.</i>
<i>Bernstein</i> , 460. <i>a.</i>	Zinc ores, 954. <i>b.</i> Silver,
Beryl, 145. <i>a.</i>	<i>ib. c.</i> Tin, 955. <i>c.</i> Lead-
<i>Bizia (pietra)</i> , 82. <i>b.</i>	ores, 956. Copper-ores,
<i>Bismstein</i> , 917. <i>c. n.</i>	959. The <i>pyrataceæ</i> , 960. <i>b.</i>
	U u u 2 Blue

1020 TABLE OF CONTENTS.

Blue chalk, 77. *b*.
 — John, 40. *a*.
 — green, red, and yellow
 colours given by iron, &c.
 163. *c. n*.
Blyertz, 451. *a*.
 Bog-ores, 7. *c*.
Bolus, 238. *a*. *Armenus*,
 239. *b*. *Induratus*, 241. *a*.
Squamosus, 242. *a*.
 Bones, their earth, 18. *b. n*.
Bononiensis (lapis), 88. *a*.
Spatum Bononiense, 88. *b*.
 Boracic acid. Its properties,
 315. How made; 516.
c. n.
 Borax. Its properties, 362. *a*.
 Bovey-coal, 482. *c*.
Brann-jord, 15. *a*.
 Bräfs, 707. *c. n*.
 Bräfs *see* Copper, 710. *c. n*.
Brassica rubra, instead of
Litmus, 277. *c. n*.
Braun Bleyertz, 781. *a*.
Braccia, 888. *a*. *Jaspidea*,
 890. *a*. *Silicea*, 890. *c*.
quartzotza, 891. *a*. *Saxosa*,
 891. *b*. *Porphyrea*, *ibid*.
arenacea, 892. *b*.
 Briancon chalk, 98. *c*.
 Brimstone, 491. *a*.
Byssus asbestinus, 115. *b*.

C.

Cabochon, what? 182. *b. n*.
 Cacholong, 181. *c*. 182. *b. n*.
Cadmia botrites, 790. *b. n*.
Cadmia Fornacum, 789. *c. n*.
Caerulium montanum, 60. *a*.
 Calamine, 775. *a*.
Calamita bianca, 239. *c. n*.
 Calcareous earth, 15. *a*.

Calcareous chalk, *idem* —
 Craie, *idem*.
 Calcareous earth, pure, 20. *a*.
 Its affinities, 73. *a*. and
 following.
 Its preperities, 938. *c. n*.
 Its varieties, 56 and fol-
 lowing; is the most dif-
 fused, 19. *b*.
 Is the earth of animal
 bones, 19. *c*.
 Sparry, 25. *c*. 76. 6. *b*.
Pblogisticated, 48. *b*.
Pulveruenta, 58. *a*. *Rubra*,
ibid.
 With copper, 60. *a*.
 With iron, 57. *b*.
 Observations on calcareous
 earth, 62. *c*. 73 and 74.
 Calcareous compounds, 50.
c. and following. 80. and
 following.
 Calcination of metals, and
 new doctrine of the same,
 511. *c. n*.
 Call, 208. *c. n*.
Calx Bathensis, 75. *b*.
Calx nitrata, 378. *a*.
Calx muriatica, 380. *a*.
Calx arrata, 381. *a*.
 Camchuya, 184. *b*.
 Campan marble, 81. *a*.
 Cannel-coal, 480. *a*.
Capnites, 790. *b. n*.
Carabé, 460. *a*.
 Carbuncle, 135. *b. n*.
Carbunculus, *ibid*.
 Carnelian, 185. *a*.
Carniolus, 185. *a*.
Carpolithi, 884. *c. n*.
Caryophylloides, 109. *c*.
 Cassius, his powder, 623. *c. n*.
 Cat's-

TABLE OF CONTENTS. — 1021

Cat's-eye, 177. <i>c.</i> —183. <i>b.</i>	How manufactured, 834. <i>b. n.</i>
Cauk, 84. <i>a.</i>	Calciiform, 828. <i>a.</i>
Cementing iron ores, 734. <i>a.</i>	With Nickel, 832. <i>b.</i>
<i>Cerusa nativa</i> , 61. <i>c.</i>	With Iron, 830. <i>c.</i>
<i>Cerusa</i> , how made? 648. <i>b. n.</i>	Combined with arsenical acid, 829. <i>c.</i>
Chalcedony, 181. <i>b.</i>	Its assay in small quantities, 836. <i>c. n.</i>
Chalk-stone, 22. <i>b. idem granulatus</i> , 23. <i>b.</i>	Observations on it, 832. <i>c.</i>
<i>Chalumeau</i> (<i>l'erre à</i>), 99. <i>b.</i>	Wrong and vulgar notions of cobalt, 837. <i>a.</i>
Charcoal, what? 486. <i>a.</i>	Cockle crystallised, 211. <i>a.</i>
Charcoal (the fittest for the Effays), 934. <i>b.</i>	Cockle spar, 148. <i>a.</i>
<i>Chatoiantes</i> (<i>pierres</i>), 162. <i>c. n.</i>	Cockles, 202. <i>b.</i> —207. <i>b.</i>
Chert, 189. <i>c.</i>	Colnish clay, 234. <i>b.</i>
Observations on Cherts, 190. <i>b.</i>	Colours of acids (succession of): these are seen but by refracted rays, 278. <i>b. n.</i>
Chrysolite, 142. <i>b.</i> —145. <i>b. n.</i>	Colours, (various) shewn by iron with heat, 753. <i>c. n.</i>
Chrysoprase, 143. <i>c. n.</i>	Colours, (various) given to hard stones by iron, 163. <i>c. n.</i> —81. <i>b.</i>
Cinnabar, 593. <i>a.</i> The last in being revived, <i>ib. b. n.</i>	Colours, their natural succession, 278. <i>b. n.</i>
Cipolin marble, 82. <i>c.</i>	<i>Columbina</i> (<i>pietra</i>), 82. <i>a.</i>
Circoncision-stone, 176. <i>b.</i>	Combustibles, what? 434. <i>b. n.</i> New doctrine, <i>ib.</i>
Clay, 227. <i>a.</i> Its properties, <i>ib. &</i> 941. <i>b. n.</i> For refining sugar, 270. <i>b. n.</i>	Combustion, 435. <i>b.</i> and following.
Common plastic clay, 254. <i>c.</i>	Combustion (the new doctrine of it), 492. <i>b. n.</i>
Its formation, 263. <i>a.</i>	<i>Contrefait</i> , 784. <i>b. n.</i>
Observations on clays, 267. <i>a.</i>	Copal, 464. <i>b. n.</i>
Clay-marle, 54. <i>b.</i>	Copper. Its qualities, 671. <i>a.</i>
Coaks, 490. <i>b.</i>	Its thin leaves how gilt at Nuremberg? 672. Native Copper, 678. <i>b.</i> Calciiform Copper, 681. <i>a.</i> and 684. <i>a.</i> Red copper ore, 683. <i>a.</i> Cupreous stones, U u u 3 685.
Coaks (how made), 490. <i>b. & c. n.</i>	
Coals (their origin), 486. <i>c. n.</i>	
Scotch coals, 489. <i>a.</i>	
Observations on fossil coals, 485. <i>c.</i>	
Coal (slate), 479. <i>a.</i>	
Cobalt. Its properties, 823. <i>a.</i> and 964. <i>b.</i>	
Native, 826. <i>a.</i>	

1022 TABLE OF CONTENTS.

685. *b.* Mineralized, 687. *Oreta alba*, & *friabilis*,
b. Pyritous, 689. 692. 21. *a.* *indurata*, 22. *b.*
960. *b.* White copper ore, *granulated*, 23. *b.* *Spathefa*,
693. *a.* with arsenic and 24. *b.*
zinc, 694. *b.* with vitri- *Oreta Brianzonica*, 103. *c.*
olic acid, 695. with mu- Crystall, (rock) 168. *b.*
riatic acid, 696. Copper Crystallization of gems, 164.
coal ore, 698. *a.* Observa- *b.* *n.*
tions on copper, 698. *b.* Crystals, (artificial) by A-
Verdegris, 702. *b.* *n.* Is a chard, Bergman. 222. *c.* *n.*
poison. Poisonous quali- 223. *b.* *n.* and by Morveau.
ties of its vessels in the *Addit.* to pag. 223.
kitchen, 703. *b.* *n.* and Crystals, (pebble, milk) 173,
following. *Cryst. ill. s. montana*, 168. *b.*
Copper-ore of various co- Cubic nitre, 355. *b.*
lours, 688. *c.* *n.* Cubit (Egyptian), 148. *b.* *n.*
Copper of cementation, 695. Culm coal, 477. *a.*
good, how made? 705. *Cupri (min. a.) Calciformis*,
b. *n.* white copper, 710. *a.* 959. *a.*
Copper, when melted, ex- *Pyritacea*, 960. *b.*
plodes by vapour, 675. *Cuprum salitum*, 403. *a.*
b. *n.*
- Copperas-stone, 497. *a.* D.
Coral-stone, 186. *c.* *n.* Daze, 106. *c.*
Coralina, (Oriental) 145. Dephlogisticated air, 435. *b.*
c. *n.* *See* Vital air.
Corium (five caro) *montanum*, Derbyshire Spar. 26. *b.* *n.*
114. *b.* Destruction that acts priva-
Coro-shut marle, 54. *b.* tive, 6. *c.* *n.*
Corpora peregrina, impreg- Detonation of Nitre, 347.
nated with pit-coal, 904. *a.* *c.* *n.*
petrales, *ceu asphaltis*, *ibid.* *c.* Detonation of two airs,
pyritacea, *ibid.* *c.* 445. *c.*
Coruscation (*eclair*), of Me- Diamantine Spars. *See Ad-*
tals, 155. *c.* *n.* *dation* to p. 133.
Cos Turcica, 216. *b.* Diamond, 123. *a.* How and
Countries, in Mineralogy, where found, 123, 124,
2. *c.* and 128. *c.* *n.*
Craie de Champagne, 77. *b.* Diamonds how valued, 129.
Crawford's doctrine of com- *b.* *n.*
bustion, 439. *b.*
- Crenor Calcis*, 31. *a.* *n.* Diamonds,

TABLE OF CONTENTS 1023

Diamonds, the most extraordinary, 130. <i>b. n.</i>	Earths, Ponderous, 84. <i>a.</i>
Cubic Diamonds, <i>Addit.</i>	—— Magnetian, or Muratic, 93. <i>a.</i>
19 <i>pag.</i> 125.	—— Siliceous, 120. <i>a.</i>
Are a coagulated phlogiston, 131. <i>b. n.</i>	—— (infusible) 941. <i>c. n.</i>
<i>Oriental</i> and <i>Occidental</i> , are false distinctions, 125. <i>c. n.</i>	—— which change their colour with fire, 943. <i>c. n.</i>
Coloured diamonds, 126. <i>b. n.</i>	—— divisible, or not, 945. <i>c. n.</i>
Their decomposition, 127. <i>c. n.</i> and 132. <i>c. n.</i>	—— fusible, 943. <i>c. n.</i>
Observations on diamonds, 127. <i>a.</i>	—— soluble in borax, 946. <i>b. n.</i>
Diamond-earth, 15. <i>c. n.</i>	—— in Microscopic salt, <i>ibid.</i>
Diaspro, 192. <i>c.</i>	—— soluble in sal soda, 944. <i>c. n.</i>
<i>Dialporsite</i> , 193. <i>b.</i>	—— with effervescence, 944. and following, <i>n.</i>
<i>florido</i> , <i>ibid.</i>	without it, <i>ibid.</i>
Brecciato, 890. <i>a.</i>	Earthy neutral salts, 377. <i>a.</i>
Digestive salt, 349. <i>a.</i>	<i>Eisen</i> , 713. <i>a.</i>
<i>Diphrys</i> , 790. <i>b. n.</i>	<i>Eisen bluth</i> , 730. <i>b. n.</i>
Domitian gem, 146. <i>b. n.</i>	<i>Eisenrum</i> , 725. <i>b.</i>
<i>Drake</i> , or <i>Druse-hol</i> , 27. <i>c. n.</i>	Elastic marble. <i>See additions</i>
Drop-stone, 29. <i>b.</i>	to page 893.
<i>Druse</i> , or <i>Drafcum</i> , 28. <i>c. n.</i>	—— sand-stone, <i>ibid.</i>
59. <i>a.</i>	—— petrol, 469. <i>a.</i>
Drusen, 28. <i>c. n.</i>	Electricity cannot pass in a perfect vacuum, 610. <i>b. n.</i>
Drying oil, 649. <i>b. n.</i>	<i>Elctrum</i> , 460. <i>a.</i>
<i>Dubbsstein</i> , <i>Doppelslein</i> , 26. <i>a.</i>	Emerald, 146. <i>a.</i>
<i>Duckstein</i> , 53. <i>a.</i> —77. <i>a.</i>	Empyrean air, 437. <i>c. n.</i>
E.	Enhydre, 182. <i>c. n.</i>
Earths, how many? 13. <i>a. n.</i>	Epsom salt, 96. <i>a.</i> 97. <i>a.</i>
—— what? 9. <i>c.</i>	Epsom salt with copperas, 421.
—— Primitive, 13. <i>b. n.</i>	<i>Erdspeche</i> , 468. <i>a.</i>
—— Derivative, <i>ibid.</i>	<i>Erhartetc.</i> , 471. <i>c.</i>
The 5 original earths, 14. <i>b. n.</i>	<i>Etain</i> , 618. <i>a.</i>
Earths, Argillaceous, 226. <i>a.</i>	Expansion of metals (Table of the), 716. <i>b. n.</i>
—— Calcareous, 15. <i>a.</i>	

1024. TABLE OF CONTENTS.

F.

- Fall-ertz*, 559. *b.*
 Falling-stars, 443. *b.*
Federertz, 557. *b.*
 Felt spar, 198. 198. *a. n.*
 ——— Its contents, *ibid.*
 198. *n.*
 What it means, *ibid. c. n.*
Fer, 713. *a.*
Ferri (minera) alba, 57. *b.*
Ferrum, 713. *a.*
Fer-blanc, how made? 640
 and 641, *c. n.*
 Flag-stone, 78. *a.* 260. *a.*
 Fetid-stone, 49. *b.*
 Flesh-coloured Tungstein,
 79. *b.*
 Flint, 174. *a.*
 Common flint, 189. *a.*
 Flint-glass, 667. *c. n.*
Flisjalm, 241. *a.*
Flos ferri, 730. *b. n.*
 Flowers of Zinz, 785. *c. n.*
 Fluor acid, 295. *a.*
 ———, Its properties, *ib.*
 Singular phenomenon of
 it, 296. *c. n.* See also
 Add. to page 42.
Fluor Spatojus, 40. *a.*—*indu-*
 ratus, 42. *c.*
 ——— 43. *a.*—*cry-*
 stallifatus, *ibid. c.*
 Fluors, observations on them,
 44. *c.*—Blue and green,
 79. *a.*
 ———, singular form of their
 fusion with gypsum. See
 Addition to page 42.
 ———, it does not produce
 siliceous earth, as Scheele
 pretended, 45. *c. n.*
 Flux, new one, of Dijon,
 575. *b. n.*

- Foliaceous silver ore, 565. *b.*
 Fossil alkali, 333. *b.*
 Fossil-coals (observations
 on), 485. *c.*
 Fossil-pitch, 471. *c.*
 Fossil-wood, 473. *a.*
Fraxinella's vapour is inflam-
 mable, 447. *c. n.*
 Fromond imitated, in glass,
 the double refracting spar,
 26. *b. n.*
 Fuller's earth, 237. *a. n.*
 ———, its varieties,
 238. *b. n.*
 Fulminating gold, 530. *b.*
 Fulminating-powder, 495.
 b. n.

G.

- Gagas, 473. *a.* 904. *b.*
 Galena, 660. *c.*
Galinaceous (lapis), 473. *a.*
 916. *b. n.*
Galitzenstein, See *Vitriolated*
 zinc, 786. *a.*
Geanthrax, 483. *b.*
Gema divi Stepbant, 187. *c.*
 Gems (observations on),
 161. *a.*
 Gems (false), 169. *c. n.* and
 170. *b. n.*
Gestellstein, 875. *b.*
 Geyser, spout of hot water,
 223. *b. n.*
Giacinto guarnacino, 153. *b.*
Giallo de Sienna (marble) 65.
 c. Antico, *ibid.*
 Gilf, 561. *c. n.*
Girafale, 178. *c. n.*
Glacies Muria, 36. *a.*
Glanz blende, 783. *a.*
Glanz kobolt, 832. *a.* & 827.
 Glass.

TABLE OF CONTENTS. 1025

- Glasf-gall, 191. *c.*
 Galena, 561. *a.*
 Glimmer, 106. *c.* 108. *a.*
 Observations on it, 110 *b.*
 Glauber's Salt, 353. *b.*
 Glist, 106. *c.*
 Gneis, 104. *c. n.* 630. *b. n.*
 Gold, its properties, 512. *a.*
 —, its ductility, 513. *a. n.*
 —, what, if acted on by
 electricity? 515. *a.* and
 in the note, *ibid.*
 —, its agents, 517. and
 in the Note.
 Gold, native, 520. *a.*
 — mineralized, 524. *a.*
 —, observations on it, and
 its mineralizations, 528. *a.*
 and 533. *b.*
 —, its yellow and green
 colours, 516. *b. n.*
 —, how coloured, 520.
 b. n.
 — (fulminating) 530. *b.*
 Gold coins alloy, 520. *b. n.*
 Monied gold in France,
 how much, 532. *b.*
 Gold naturally amalgamated
 with mercury, 590. *a.*
 Pretended gold in the ashes
 of vegetables, 581. *b. n.*
 Gorsten, 65. *a.*
 Garnet kind, 202. *b.*
 Common martialis, 204. *a.*
 Observations on the gar-
 net, thoerl, and cockle,
 212. *b.*
 Garnets, how to be tried,
 213. *c. n.*
 Garnet gem (*granatus gema*),
 205. *a.*—152. *b.*
 Garnet Syrian, 153.
 — *Soranus*, 153. *b.*
 Graberg, 72. *c.*—199. *b. n.*
 Granat-berg, 204. *b.*
 Granated (*terra*), 202. *a.*
 Granatstein, 204. *b.*
Granatus martialis, 204. *a.*
 — *crocis Martis & Jovis*,
 206. *b.*
 — *Id. Martis & Saturni*,
 207. *a.*
 Granitello, 875. *b.*
 Granites, 885. *c.*
 Granitone, 887. *c. n.*
 Greonsten, 885. *a.*
 Grey marble, 78. *c.*
 Grid-iron pendulums, 715. *b.*
 Grignard gypsum, 37. *c.*
 Griotte-marble, 81. *c.*
 Grit (Argillaceous), 260. *c.*
 Grit-stone, 895. *c. n.*
 Growan, 630. *b. n.*
 Guhr, 21. *c. n.*—34. *a.* (or
 Lac Lunæ) 231. *b.*—232.
 c. n.
 Gun-powder, 495. *b. n.*
 Guneche, 177. *c.*
 Gyps Sinter, 37. *b.*
 Gypsum, its varieties, &c. 32.
 a. and following.
 The formation of *gypsum*,
 70.
 Gypsum micaceum, 35. *a.*
 — *fibrosum*, 35. *b.*
 phosphoricum, 88. *a.*

 H.
 Hematites, 724. *b.* Black,
 727. *b.*
 — Red, 728. *a.* Yel-
 low, *ibid. c.*
 — Heterogeneous,
 729. *a.*
 Hæmatites,

1026 TABLE OF CONTENTS.

<i>Hammites</i> , 30. c. n.	— <i>Gramatique</i> , 196. c. n.
<i>Halinitrum</i> , 368. c.	— <i>Polygrammatique</i> , 196. b. n.
<i>Halotrichium</i> , 410. b.	— Agatified, 197. c. n.
Hardened Rock-oil, 471. c.	— Observations on it, 195. a.
Hardness (table of the) of various substances, 225.	<i>Jayet</i> , 473. a.
Hazel Rod, 898. b.	Iceland Agate, 917. a.
Heat, 436. c.	Iceland's volcanic explosions in 1783. <i>Addit.</i> to page 910.
<i>Heliotrope</i> , 193. a.	<i>Jern</i> , 713. a.
<i>Heliotropium</i> , (Tincture of), 277. a. n.	Jet, 473. a.
Hepatic Air, its properties, Sect. 230. p. 448. and foll.	<i>Ignis fatuus</i> , 443. b.
Homber's Phosphorous, 17. a. n.	Incombustible cloth (of Asbestos), 117. c. n.
Horn blende, 242. a.	Inflammable Air, its properties. Sect. 229. p. 441. and foll.
Hornberg, 109. c.	— its various kinds, 447. c. n.
Horn-silver ore, 563. a.	— a new one discovered by Volta, 442. c. n.
<i>Humus</i> at 1, 263. b. 269. c. 503. c. 908. b.	— water produced by deflagration, 444. a.
<i>Humus conchaceus</i> , 63. c. 900. b. 907.	Inflammables, 10. a.—433. a.
— <i>Lacusfris</i> , 908. b.	Insufible earths, when alone, 941. a.
— <i>Vegetabilis</i> , 907. c.	Ink (common), for writing, 405. b. n.
Hyacinth, 149. a. 205. b.	Ink-stones, 406. b. n.
<i>Hydrargirum</i> , 577. a.	Iris stone, 183. c.—178. c. n.
— <i>nativum</i> , 586. a.	Iron. Its properties, 713. a.
— <i>Auro vel argento adunatum</i> , 590. a.	— Native, 720. a.
Hydrophanes, 178. a.	— Calciform, 722. a.
I.	— Aerated, 406. a.
<i>Jacinta la-bella</i> , 150. c.	— Indurated, 724. b.
Jack-lanterns, 443. b.	— Mineralised, 736. b. 740. b.
Jade, 176. b.	— Refractory, 738. b.
Jargon, 132. b. & c. n.	
Jaspachates, 176. b.	
Jasper, 192. c.	
— <i>Flavus</i> , 193. b.	
— <i>martialis</i> , 194. a.	
Jasper, 15 varieties of it, 196. b. n.	

TABLE OF CONTENTS. 1027

Red grained, 739. <i>b.</i> Observations on iron, 743. <i>b.</i> Method of smelting it, 745. <i>b. n.</i> <i>Addit. to page 78.</i> New method of H. Cort, 748. <i>c.</i> and <i>sol.</i> Steel how made, 751. <i>b. n.</i> Cast steel invented by Waller, 752. <i>c. n.</i> Tempering iron, 753. <i>c. n.</i> and <i>ell.</i> its value exceeds sometimes manifoldly that of gold, 755. <i>b. n.</i> Antimony of sulphur hinders attraction to the magnet, 756. <i>c.</i> Expansion of steel, and of other substances, by heat, 756. <i>b. n.</i> De-phlogisticated iron has no binding power, 731. <i>b. n.</i> Best iron ores, 744. <i>b. n.</i> Crytallized iron, 737. <i>b. n.</i> Colours exhibited by heat, 753. <i>b. n.</i> Cementing iron-ore, 734. <i>a.</i>	<i>Kedria terrestris</i> , 468. <i>a.</i> <i>Kiese</i> , 15. <i>a.</i> <i>Kiffikil</i> , 99. <i>b.</i> —236. <i>b.</i> <i>Kiesel</i> , 189. <i>c.</i> Kilkenny coal, 480. <i>a.</i> —481. <i>b.</i> Killas, 261. <i>b.</i> <i>Kisier</i> , 31. <i>b. n.</i> <i>Kolm</i> , 477. <i>a.</i> Kolmord marble, 80. <i>b.</i> <i>Krita</i> , 15. <i>a.</i> <i>Kugeleritz</i> , 560. <i>c.</i> <i>Kupfernickle</i> , 841. <i>c.</i>
Iron. <i>Minera refractoria</i> of it, 738. <i>c.</i> — gives various colours to stones, 163. <i>c. n.</i> — ores assayed by the Blow-Pipe, 962. <i>b.</i> Iceland-spar, 26. <i>a.</i> <i>Juan blanco</i> , 497. <i>c. n.</i> <i>Juden pech</i> , 471. <i>c.</i> <i>Jupiter</i> , 618.	L. <i>Labra</i> , 218. <i>a.</i> Labrador-stone, 199. <i>a.</i> <i>Lac luna</i> , 20. <i>a.</i> —231. <i>b.</i> <i>Lacusfris</i> iron-ore, 732. <i>b. n.</i> <i>Lapis Alabandicus</i> , 154. <i>a.</i> — <i>A-menus</i> , 60. <i>c.</i> —685. <i>c.</i> — <i>Bmoniensis</i> , 88. <i>a.</i> — <i>Calaminaris</i> , 775. <i>a.</i> — <i>Calcareous</i> , 22. <i>b.</i> — <i>Corneus</i> , 189. <i>c.</i> —207. <i>c.</i> — <i>Corneous Crystallizatus</i> , 207. <i>c.</i> — <i>Crucifer</i> , 212. <i>a.</i> — <i>Electricus</i> , 154. <i>b.</i> — <i>Gallinaceous</i> , 473. <i>a.</i> —916. <i>b. n.</i> — <i>Hepaticus</i> , 91. <i>a.</i> —93. <i>c. n.</i> —475. <i>c.</i> — <i>Lazuli</i> , 247. <i>a.</i> — <i>Lydius</i> , 882. <i>c.</i> —883. <i>c. n.</i> — <i>Molaris Rhenanus</i> , 917. <i>c.</i> — <i>Nephriticus</i> , 176. <i>b.</i> — <i>Obsidianus</i> , 473. <i>a.</i> —916. <i>b. n.</i>
K. <i>Kalekatrige eden</i> , 15. <i>a.</i> <i>Kalk-jord</i> , 15. <i>a.</i> Kanel-coal, 480. <i>a.</i> Kaolin, 232. <i>b.</i>	

Lapis

1028 TABLE OF CONTENTS.

- Lapis Ollaris*, 234. *b.*
 — *Spatofus*, 24. *b.*
 — *Suillus*, 49. *b.*—475. *a.*
Larva calcarea & cretacea, 900. *a.*
 — *Spatofa*, 901. *a.*
 — *Silicea & argillacea*, 902. *b.*
 — *Insalita & phlogistica*, 903. *a. c.*
 — *Pyritacea and metal-
 lifera*, 904.
 — *Argentifera & Cupri-
 fera*, 905.
 — *Terrifera & sulphure-
 conferta*, 906. & 907.
 — *Hematitica*. *ibid.*
Lavas (volcanic), 909. *a.*
 —, antiquity of their
 layers, 921. *b. n.*
 —, compact and vitreous,
 922. *c. n.*
 —, their component parts,
 923. *b. n.*
Lead, its properties, 644.
 and following.
 —, its succession of co-
 lours, 650. *a. n.*
 —, Native, 651. *a.*
 —, Calciform, 652. *c.*
 —, Mixt, 656. *a.*
 —, Mineralized, 658. *a.*
 —, by the phosphoric acid,
 659. *b.*
 —, with silver, 660. *c.*
 —, with antimony and
 silver, 664. *a.*
 —, its sandy ore, 665. *b.*
 —, weight of its mixtures,
 625. *c. n.*
- Lead*, a mixture of it that
 melts before water boils,
 649. *b. n.*
 —, observations on, 666. *a.*
 —, how made into sheets,
 668. *n.*
 —, its granulation, 640.
c. n.
 —, how made into shot,
 669. *b. n.*
 —, is very noxious to
 animals, 670. *b. n.*
 —, its danger in four
 wines, 671. How disco-
 vered, *ibid.*
Leberertz, 557. *b.*
Leberstein, 91. *b.*
Lemnia (terra), 236. *c.*—
Light, 436. *c.*
Limsten, 24. *b.*
Liquor probatorius vini, 671.
b. n.
Lithanthrax, 476. *a.*
Litharge, 645. *b.*
Lithomarga, 235. *a.*
Litmus (or *Lackmus*), its
 tincture, 989. *a.*—277. *a.*
n. Its *succedaneum*, *ib. c.*
Liver-stone, 92. *b. n.*—475. *c.*
Looking-glasses how made,
 608. *b. n.*
Ludus Helmontii, 888. *b. n.*
Lumachella, 889. *b.*
Lupus Jovis, 866. *b. n.*
- M.
- Macigno*, 82. *b.*
Magnesia alba, 93. *a.*—940.
c. n.
 ————— to purify it,
 94. *b. n.*
Magnesia

TABLE OF CONTENTS. 1029

<i>Magnesia alba</i> , with acids, 97. <i>a.</i>	<i>Manganefium Salitum</i> , 414. <i>a.</i>
_____ with other earths, 98. <i>a.</i>	Marbles, 65. <i>c.</i>
_____ aerated, 388. <i>b.</i>	Italian marbles, <i>ibid.</i> and following.
_____ nitrated, 386. <i>b.</i>	Cautions on <i>Collections</i> or <i>Studi</i> of marbles from Italy, 69.
_____ <i>Salita</i> , 387. <i>b.</i>	<i>Marcafita officinalis</i> , 757. <i>a.</i>
_____ vitriolated, 384.	<i>Marcafites</i> , 498. <i>c. n.</i>
_____ its compounds, 118. & 119.	<i>Marcafittical</i> copper ore, 499. <i>a.</i>
Magnesian copperas, 421. <i>b.</i>	<i>Marcafittical</i> gold-ore, 525. <i>b.</i>
Magnesian earth (its properties) 940. <i>c. n.</i>	Marle, <i>Marga</i> , 50. <i>c.</i>
Magnesian spar, 215. <i>c.</i>	Marle and arable land, 53. <i>c.</i>
Magnetical attraction, 737. <i>c. n.</i>	varieties of marl, 54. <i>b.</i>
Malachites, 61. <i>b.</i> —682. <i>b. n.</i>	<i>Marmor metallicum</i> , 88. <i>a.</i>
<i>Maliba</i> , 468. <i>a.</i>	_____ <i>druficum</i> , 89.
Manganese, <i>Manganefium</i> , 848. <i>b.</i>	<i>Marn</i> , 50. <i>c.</i>
_____, is a true semi-metal, <i>ibid.</i> <i>c. n.</i>	<i>Mars</i> (iron), 713. <i>a.</i>
_____, is magnetical when powdered, 849. <i>c. n.</i>	Martial (green) vitriol, 404. <i>a.</i>
_____, Native, 852. <i>a.</i>	Martial muriatic spar, 215. <i>c.</i>
Native calces of it, 854. <i>b.</i>	Martial pyrites, 406. <i>b. n.</i> —740. <i>b.</i>
If well phlogifticated turns white, 854. <i>c. n.</i>	Mafficot, 646. <i>b. n.</i>
_____, white and red, 855. <i>a.</i>	<i>Meerfhaum</i> , 99. <i>b.</i>
_____, black, 857. <i>b.</i>	<i>Melites</i> , 193. <i>c.</i>
_____, it is the <i>Perigord flone</i> , 858. <i>c. n.</i>	Melons of Mount Carmel, 5. <i>b.</i>
_____, in the <i>Black wadd</i> , 859. <i>b.</i>	<i>Memphites</i> , 184. <i>a.</i>
_____, in vegetables, <i>ibid.</i>	Mercury. See Quickfilver, 577. <i>a.</i>
_____, Observations on it, 860. <i>b.</i>	_____, its specific gravities, 612. and following, <i>n.</i>
_____, is contained in many iron ores, 861. <i>c. n.</i>	_____, mistake of Boerhaave on it, 614. <i>b.</i>
	_____, blunders in barometrical observations, 616. <i>c. n.</i>
	_____, is not contained in lead, 592. <i>b. n.</i>
	_____, why it feels cold, 609. <i>b. n.</i>
	Mercury

1030 TABLE OF CONTENTS.

Mercury sublimate corro-	Mineral alkali, 333. a.
five, its great efficacy.	Mineral tallow, 455. a.
611. b.	Minerals, their formation,
Metallic expansions by heat,	1. b.
716. b. n.	———, their growth, 3. b.
Metallic compound which	———, by precipitation,
melts before water boils,	6. c.
649. c. n.	———, by subterranean
Metallic salts, 400. a.	fires, 7. a.
Observations on them,	———, by privative de-
415. a.	struction, 6. c. n.
Metallic substances, their	———, their general di-
general properties, 506. a.	vision, 9. c.
Metals, 11. a.	Mineralizers of metals, 511.
———, their crystallization,	b. n.
510. b. n.	Mineralized metals, viz.
———, their melting heat,	Their habitudes in the
508. b. n.	fire, 965. c. n.
———, table of these heats,	<i>Minera anen-cæ</i> , 895. a.
509. n.	896. c. n.
———, their calcination,	——— <i>Phlogisticæ Cupri</i> ,
511. c. n.	<i>ferri</i> , &c. 501.
———, the new doctrine	<i>Minium</i> how made, 645. n.
about it, <i>ibid.</i>	<i>Mirabile (sal) glauberi</i> , 353. b.
Metals found also in lavas,	Mispickel, 741. a.
910. b. n.	Mocha-stone, 185. c. — 187. b.
<i>Mica alba</i> , or Muscovy glass,	Mock-lead, 499. b. — 779. a.
<i>Mica lamellis parallelis</i> , 108. a.	Molybdene, its properties,
——— <i>squamosa</i> , }	863. a.
——— <i>acerosa</i> , }	———, how distin-
——— <i>convorta</i> , }	guished from plumbago,
<i>M. martialis colorata</i> , 109. a.	863. b. n.
——— <i>drusica</i> .	Molybdenic acid. Its pro-
——— <i>black</i> .	erties, 301. a.
——— <i>green</i> .	——— different from
——— <i>drusa</i> .	the Volfranic or Funyste-
Observations, 110. b.	mic acid, 304. c. n.
Artificial mica, 112. c. n.	Moon-stone, 183. c.
Microcosmic salt, 946. a. n.	Moor-stone, 885. c. n.
Mild vegetable alkali, 351. b.	Mould, 907. c.
Milk-crystals, 173. b.	<i>Mumia</i> , 455. a. — 472. b.
Mineral agaric, 20. a.	<i>Mumia</i>

TABLE OF CONTENTS. 103

- Mimia vegetabilis*, 904. *b.*
Muria Cbrysolampis, 40. *a.*
 Muriac acid, 290. *a.*
 Its properties, *ibid.*
 Its saturations, 292. *b. n.*
 Muriac barytes, 382. *c.*
 — chalk, 280. *c.*
 — earth, *Terra muria-*
 tica, 93. *a.*
 — copper, 403. *a.*
 — magnesia, 387. *b.*
 — manganese, 414. *a.*
 — spar, 215. *c.*
Murksten, 876. *c.*
Muscoviticum (vitrum), 108. *a.*
Muscovy glass, 113. *a.*
- N.
- Naphia*, 465. *a.*
Natron, 367. *a.*
Negrillo, 559. *c. n.*
Nephriticus, (*Lapis*), 102. *b.*
Nero di Fiandra (marble),
 65. *c.*
Nero di Prato, 106. *b.*
Neronian gem, 146. *b. n.*
 Neutral salts, 340. *a.*
 Observations on them,
 375. *b.*
Nickel. Niccolum. 837. *b.*
 965. *b.*
 —, attracts iron, 838.
 c. n. 840. *c. n.*
 — native, 840. *b.*
 — calciform, 841. *a.*
 — vitriolated, 842. *b.*
 — observations on it,
 843. *a.*
 — is a true semi metal,
 sui generis, 848.
Nihil, 785. *c.* 790. *b. n.*
- Nihil album*, *ibid.*
 Nitre (common), 344. *a.*
 — native is found in
 Naples. 'See *Addition to*
 page 346.
 Nitre (cubic), 355. *b.*
 Nitre of lime. *Calx nitrata*,
 378. *a.*
 Nitrated magnesia, 386. *b.*
 Nitrous acid, its properties,
 284. *a.*
 — pretended formation
 of it, 286. *b. n.*
 — does not dissolve gold,
 289. *c. n.*
 — its saturation by
 metals and earths, 289. *b. n.*
 — ammoniac, 371. *a.*
 Noble and perfect metals,
 512. *a.*
- O.
- Oculus Mundi*, 178. *a.*
 Observations on it, 180. *a.*
Ofenbrueh, 789. *c. n.*
Ollaris (lapis), 104. *b.*
Onychites, 790. *b. n.*
Onix camebusa, 184. *a.*
Olithas, 30. *a.*—76. *c.*
Opal, 157. *b.*
 —, artificial, 161. *b. n.*
Oriental and occidental deno-
minations of gems, are
arbitrary, 125. *c. n.*
Orpiment, 816. *b.*
 — probatory liquor
 made by it, 822. *c. n.*
 — how it may be in-
 effectual, 823. *b. n.*
Osmundian argilla, 237. *c. n.*
- Osteocola,

1032 TABLE OF CONTENTS.

- Osteocola, 77. *a.*
 Oxygene (oxigene) principle, 435. *b. n.*
- P.
- Pacros*, 157. *b.*
Panormitana (*calx nativa*), 20. *b.*
 Paper-marle, 54. *b.*
Paragone antico, 193. *b.*—
 —196. *c. n.*
 Parget, 32. *a.*
 Parian-marble, 68. *b.*
Pavonium, 196. *b. n.*
 Pearl slag, 918. *k.*
 Peat, 483. *b.*
 Pebbles, 189. *b.*
 Pebble-crystals, 173. *b.*
Pecblende, 560. *b.*
 Peridot (is the chrysolite), 142. *c. n.*
 Perigord stone, 858. *b. n.*
 Peru emerald, 145. *b. n.*
 Petrefactions, 873. *a.*
Petrefacta, or *Petrifications*, 898. *c.*
Petrefacta Calcarea, 900. *b.*
Spatoſa, 901. *a.* *Sili.ca*, 902. *a.* *Inſalita*, 903. *a.*
Petrefacta Lithantracea, 904. *a.*
 ——— *Petroleo*, ceu afphalto impregnata, 904. *a.*
 ——— *Pyritacea*, *ibid. c.*
 ——— *Argentifera*, 905. *b.*
 ——— *Cuprifera*, *ibid. c.*
 ——— *ferrifera*, 906. *c.*
Petroſilex, 189. *b.*
 Petrol (*Petroleum*), 467. *a.*
 Elastic petrol, 469. *a.*
Petroleum tenax, 468. *a.*
 ——— *induratum*, 471. *c.*
- Petunſe*, 198. *a.*
 Pewter, 642. *b. n.*
 It is generally mistaken abroad, and called *tin*, or *etain*, 643. *b. n.*
Phlogiſta mineralia, 433. *a.*
 Phlogiſton, 436. *a. n.*—441. *c. n.*
 ——— Its exiſtence, 442. *b. n.*
 ——— *Addit. to page 445.*
 ——— with aerial acid, 452. *b. n.*
 ——— with earths, 475. *a.*
Phosphorus of Kunkel; how to make it, 311. *b. n.*
 ———, how made its acid in a fluid form? 313. *c. n.*
 ——— precipitates metals from their ſolutions, 314. *c. n.*
 Phosphoric acid. Its properties, 310. *a.*
 Phosphoric appearance in the barometer, 610. *a.*
Phosphorus nativus, 88. *a.*
Piedra d'el Ynea, 497. *b.*
Pierre de St. Ambroix, 83. *a.*
Pietra Columbina, 82. *a.*
Pietra Columbina Bigia, *ibid.*
 Pip-lera, 240. *c. n.*
 Pipe-clay, 234. *a.*
Pisolithes, 30. *a.*—76. *c.*
 Pit-coal, 476. *a.*
 Pitch-blende, 780. *a.*
 Pitch (fossil), 471. *c.*
Pix montana, 471. *c.*
 ———, *impure*, 472. *b.*
Placites, 790. *b. n.*
 Plaster, its contents, 32. *c. n.*
 Plaster-stone, 32. *a.*
 Platine.

TABLE OF CONTENTS. 1033

Platine. <i>Platinum</i> . Its properties. 567.	Potter's ore, 661. c. n.
— how rendered malleable, 574. a. n.	<i>Potzevera</i> , 106. a.
— method of Mr. Aachard, 576. b. n.	Prase, 144. c. n.
— its specific gravities, 571. b. n.	Precious stones falsely called <i>Oriental</i> or <i>occidental</i> , 125. c. n.
Plumbago, its properties, 451. a.	Precious stones (observations on), 161. a.
Plumbago of iron, 453. c. n.	Precious stones analyzed, 161. b. n.
Plumbum, 644. a.	Prince's metal, 708. b.
<i>Plumbumustum</i> , 645. b. n.	Probatory liquor of orpiment, 822. c. n.
Pocket Laboratory (The Dry) 929. b. 977.	Prussian blue, native, 733. a.
— (The Humid), 988. b.	Pseudo-agate, 159. c. n.
— (The Lamp Furnace), 991. c.	Pseudo-galena, 778. b. n.—
Polarity of attraction, 429. c. n.	<i>Pseudopalus</i> , 177. b.
Poles (false) of electricity, 155. b. n.	Pudding-stone, 82. b.
<i>Pompholix</i> , 790. b. n.	<i>Pulvis pyrophorus</i> , 397. b.
Ponderous earth, 84. a.— 940. b. n.	Pumice stone (<i>pumex</i>), 917. c.
— spar, 85. c. n.	Purbeck stone, 78. a.
— aerated, 87. a.	Putty, 643. c. n.
— drusen, 89. b.	<i>Puzzo'ana</i> , 72. b.
— <i>vitriolata</i> , 382. a.	Pyritaceous lime-stone, 83. a.
Ponderous earth (its properties), 940. b. n.	<i>Pyrit. s. subflavus</i> , 497. b.
Pont-marle, 54. b.	— <i>rufescens</i> , 498. a.
Porcelain earth, 103. b.— 232. b.	Pyritical gold-ore, 499. c.
<i>Porfido</i> , 879. a.	Pyrometer of Wedgwood, 228. a. n.
<i>Pori</i> , 77. a.	<i>Pyromachus</i> , 189. a.
Porphyry, (calcareous) 83. a.	<i>Pyrophorus</i> , 283. b.—397. c. n.
Porphyry, 879. a.	
<i>Porphyrites</i> , 879. a.	Q.
Portland-stone, 78. a.	Quartz, 165. a.
Potters lead-ore, 499. b.	— rock crystal, 168. b. and 172. a.
	— heterogeneous, 171. a.
	— its seven species, 174. b. n.
	— observations, 172. b.
	P p p Quartz,

1034 TABLE OF CONTENTS.

- Quartz, rhombic, 198. *a.*
 Quicksilver. Its properties, 577. *a.*
 — is a perfect metal, 579. *b. n.*
 —, its specific gravities, 612. *a. n.*
 — Native, 586. *a.*
 — united to gold and silver, 590. *a.*
 — mineralised, 593.
 — Cinnabar (pure), 593. *a.*
 —, Cinnabar (impure), 596. *a.*
 —, with iron and sulphur, 597. *b. n.*
 —, with marine and vitriolic acids, 602. *a.*
 — reduced into vapours, 579. *c. n.*
 —, red precipitate, 583. *b. n.*
 —, mines of, 586. *c. n.*
 — Turbith mineral, *ibid.* *c. n.*
 —, *Æthiops perse*, 579. *a. n.*—585. *b. n.*
 —, precipitate *perse*, 578. *c. n.*
 — Pyritous cinnabar, 597. *c.*
 — Pyritous mercurial ores, 600. *a.*
 —, observations on, 603. *a.*
 —, its amalgamations, 606. *b. n.*
 — is the most effective medicine, 611. *n.*
 R.
 Ragg-stone, 217. *a.*
 Rainbow-stone, 183. *b.*
Rapakivi, 887. *c. n.*
Rauch Topaz, 169. *b.*
 Red cabbage instead of *Litmus*, 277. *b.*
 Red-lead how made, 645. *b. n.*—646. *b. n.*
 Refraction (double) of the Islandic spar, 26. *a.*
 —, imitated in glass by Fromond, 26. *b. n.*
Reisbley, 451. *a.*
 Rhenish mill-stone, 917. *b.*
 Rock-crystal. See Quartz.
 Rock-oil, 465. *a.*
 — Hardened rock-oil, 471. *c.*
 — How found, 466. *b. n.*
 Rhombic quartz, 198. *a.*
 Rotten-stone, 253. *c. n.*
Rotbgulden, 551. *b.*
 Rowley rag, 215. *a.*
 Rubble-stone, 65. *a.*
 Rubicell, 136. *a.*
Rubino di Rocca, or *Rubinus raphium*, 136. *c. n.*—153. *b.*
 Ruby, 134. *a.*
 —, how made by art, 136. *b. n.*
 —, mother of, 136. *a.*
Ruffigtes-ertz, 553. *c.*
 S.
Sädig, 725. *b.*
Sal ammoniacum fixum, 17. *b.*
 — 39. *a.*
 — native ammoniac, 372. *b.*
Sal fontanum, 361. *a.*
 Sea Salt, (common), 357. *b.*
Sal gemmæ, 359. *b.*
Sal marinum, 360. *a.*
Sal montanum, 358. *a.*
 Sal

TABLE OF CONTENTS. 1035

- Sal mirabile glauveri*, 353. *b.*
 336. *b.*
Salis medii Metallici, 400. *a.*
 — observations on them, 415. *a.*
 Salpetre, 344. *a.*
 Salt (common) with magnesia, 420. *b.*
Saltska, 39. *a.*
 Salts, 10. *a.* 272. *a.*
 — are they reducible to one another? 286. *a. n.* 275. *b. n.*
 — observations on salts, 428. *a.*
 — their incombustibility, 430. *c. n.*
 — their formation, 430. *c. n.*
 Salts (earthy), 377. *a.*
 Salts (metallic), 400. *a.*
 Salts (neutral), 340. *a.*
 Salts (triple), 417. *a.*
Salt-flag, 23. *b.*
 Sancti Stephen's Stones, 77. *c.*
Santi Stephani gemma, 187. *c.*
 Sand-iron, 730. *c. n.*
 Sandiver, what? 191. *c.*
 Sand-stone, 892. *c.* with various granules, *ibid.*
 Sapphire, 137. *a.*
 Sapphires better than rubies for jewelling watches, &c. 139. *c. n.*
 Sárdea, 187. *c.*
 Sardonyx, 185. *b.* 186. *c.*
 Saturnite, 870. *c.*
Saxa composita, 874. *a.*
Saxa conglutinata, *ibid.* and 888. *a.*
 — observations on *Saxa* and Stones, 897. *a.*
Saxum Danemoreuse, 880. *c. n.*
Saxum Sablbergense, 82. *b.*
 Scheele's doctrine of heat, phlogiston, and fire, 436. *c. n.*
Schisti, 256. *c.*
Schistus Aluminaris, 395. *b. n.*
 — Bituminous, 259. *b.* 479. *c. n.*
 — Pyritaceous, 258. *c.*
 — regularis, 257. *c.*
Schoerlus Bergmani, 207. *b.*
 — crystallifatus, 211. *b.*
 — fibrous, 209. *c.*
 — spatiosus, 209. *a.*
 Schörls, or Shirls, 202. *a.* 207. *b.*
 — sparry, 209. *c.*
 — are electrical, 155. *c. n.*
 Shiril crystallized, 211. *b.*
 Stangen Shoerl, 211. *c. n.*
 — observations on shirls, garnets, and cockles, 212. *b.*
Schwach, Schwarstein, 882. *a.*
Schwarzkeil, 882. *a.*
Schwartz guldenortz, 559. *c. n.*
Scoria vulcanorum, 909. *a.*
 Scotch-coals, 489. *a.*
 Sedlitz, or Seydshutz Salt, 96. *a.*
 Selenites, 36. *a.*
 Serpentine stone, 106. *b.*
 — zoebnitz, 193. *a.*
Serpentino antico, 879. *b.*
Serpentinus (lapis), 101. *a.*
 — observations on them, 105. *b.*
Serum minerale, 455. *a.*
 Sexterces, their value, 158. *c. n.*
Sigiliata rubra, 239. *c. n.*
 Siderite, 869. *a.*
Silber baltigerkies, 561. *b.*
Silber-

1036 TABLE OF CONTENTS.

- Silberartiges*, 565. *b.*
Silix, 174. *a.*
 Siliceous earths, 120. *a.* 941.
 b. n.
 — observations on it, 217. *c.*
 Siliceous muriatic spar, 215. *c.*
 Silver, its properties, 535. *a.*
 — the purest, 539. *c. n.*
 — native, 540. *b.*
 — united to gold, 543. *a.*
 — naturally alloyed, 543. *a.*
 — mineralised, 547. *c.*
 — Arsenico-martial, 550. *a.*
 — red or ruby silver ore, 551. *b.*
 — with arsenic and iron, 553. *b.* 556. *a.*
 — with copper and iron, 554. *a.*
 — with lead, 561. *a.*
 Silver from lead, 544. *c. n.*
 — Plumose, 556. *b. n.* 557. *b.*
 — and covered with mercury, 590. *a.*
 — with copper and antimony, 559. *c.*
 Silver is generally contained in lead, but seldom in a quantity worth its separation, 544. *c. n.*
 — antimony, 557. *a.*
 — with antimony and barytes, 562. *a.*
 — with cobalt and sulphur, 558. *a.*
 — with zinc, 560. *b.*
 Silver goose-dung ore, 564. *b.*
 Horn silver ore, 563. *a.*
 Combustible, 562. *c.* 565. *b.*
 Observations on Silver, 565. *a.*
Silber schwarz, *Silber mulm*, 553. *b.*
Singel, 189. *b.*
 Sinople, 194. *a.* Variagated, *ibid. c. n.*
 Sinter, 30. *b.*
 Sinter gyps, 37. *b.*
Skjolige, 101. *b.*
 Skiorl Spar, 148. *b.*
 Slag Sand, 919. *b.*
 Observations on volcanic flags, 919. *c.*
 Slate, *Schistus*, 256. 3. *c.*
 — *Tegularis*, 257. *a.*
 — *Scriptorius*, 258. *b.*
 Slate-coal, 479. *a.*
 Smalt, 835. *c. n.*
Smaragdus gemma, 146. *a.*
Smetlis, 98. *c.*
 Soap-rock, 80. *b.* 100. *b.*
 Soap-stones, 100. *b. c. n.*
 Soil (arable), viz. observations on it, 53. *c.*
Soramus (garnet), 153. *b.*
 Spar, calcareous, 25. *b.*
 — islandic, 26. *a.*
 — imitated in glass, 26. *b. n.*
 — its form, 27. *b. n.*
 Spar like gypsum, 36. *a.*
 Sparry fluor, 40. *a.* 43. *a.*
 Observations on fluors, 44. *c.*
 Sparry fluor produces not siliceous earth, 45. *c. n.* but corrode glass, *ibid.*
 Spars (adamantine). See Addition to page 133.
Spathum calcareum, 25. *c.*
 Spathum

- Spathum Rhomboidale*, 26. *b.*
Coniformis, 30. *a.*
 ——— *Islandicum*, 26. *a.*
 ——— *Lamellosum*, 27. *a.*
Spath crystallen, 28. *a.* *Spath*
drusen, *ibid.*
Spatum, Scintilans, 198. *a.*
 ——— *versicolor*, 199. *a.*
 ——— white, 200. *b.*
 Observations on it, 201. *b.*
Spathig gyps, 84. *b.*
Spathitiger gyps, *ibid.*
 Specific gravities (table of),
 225.
 * *Specific gravities*, a new ba-
 lance for this operation,
 1007. *a.*
Speculums (metal for), 711.
b. and *c.* *n.*
Speiss, 741. *c.* *n.*
Spelter, 769. *b.*
Spiauter, 769. *b.* 784. *b.* *n.*
Spinell ruby, 136. *a.*
Spodium, 790. *b.* *n.*
 Spring Sea salt, 361. *a.*
Spuma lupi, 866. *c.*
Spuma maris, 99. *b.*
Stahlstein, 57. *b.* 729. *a.*
Stahlstein, 25. *a.*
Stalactites calcareous, 29. *b.*
Stalactites globosus, 29. *c.*
Stalactites coniformis perfora-
tus, 30. *b.*
Stalactites and Stalagmites,
 76. *b.*
Stangen Shoerl, 211. *c.* *n.*
Stannum, 618. *a.*
Stannum corneum, 624. *c.* *n.*
Stautites, 80. *b.* 100. *b.*
Martialis, 104. *a.*
 ——— Pure, 209. *a.*
Steel. See Iron, 751. *b.* *n.*
Steel-marle, 54. *b.*
- Steinoel*, 467. *a.*
Steinpech, 471. *c.*
Stellsten, 875. *b.*
 St. Stephen's Stones, 77. *c.*
 Stone coal, 476. *a.*
 Stone icicle, 29. *b.*
 Stone marrow, 235. *a.*
 Stone slate marle, 54. *b.*
 Stone turf, 484. *b.*
 Stony, or sandy ore of Lead,
 665. *b.*
Storgrafwa, 24. *b.*
Suber montanum, 115. *a.*
Succinum, 421. *a.* 460. *a.*
Succinum nigrum, 473. *a.*
 Succinous acid, its proper-
 perties, 318. *a.*
Sulphur, 491. *a.*
 Its composition by Stahl,
ibid. New doctrine on
 it, 492. *b.* *n.* and objec-
 tions, *ibid.*
Sulphur, (native) 493. *c.*
 Its liver, 494. *c.* *n.*
Sulphur metallis saturatum,
 497. *a.* 499. and foll.
 with metallic earths, 501.
a.
 Sulphureous coal, 481. *c.*
Sulphuris magister, 494. *c.* *n.*
 Swampy iron-ore, 732. *b.* *n.*
 Swine spar, 475. *a.* 49. *b.*
 Swine stone, 49. *b.*
- T.
- Table (analytical) of thirteen
 magnesian compounds,
 118 & 119.
 * ——— of precious Stones, .
 165. *b.* *n.*
 * ——— of various Clays, 238.
c. *n.*

1038 TABLE OF CONTENTS.

- * — of comparative hardness and specific gravities, 225.
- * — of various minerals, 225. *a.*
- * — of Wedgwood and Fahrenheit's Thermometers, 230. *n.*
- * — of metallic expansions, 716. *b. n.*
- * — of the melting heat, specific gravity, saturating phlogiston, and attraction of it by different metals, 509. *a. n.*
- * — of the saturation of pure vitriolic acid, with metals, alkalis, and earths, 282. *b. n.*
- * — of pure nitrous acid with the same, 289 & 288. *c. n.*
- * — of pure muriatic acid with the same, 292. *b. n.*
- Talc, or Mica, 108. *a.*
- Talcum officinale, 109. *b.*
- corneum, 242. *b. n.*
- striatum, niten, ibid.
- Talehina, (pietra) 80. *c.*
- Tallow, (mineral) Sect. 232. p. 455.
- Tarninge Spath, 88. *a.*
- Tartarus vitriolatus, 283. *b.*
- Taub Kohle, 482. *c.*
- Taufstein, 211. *c. n.*
- Telgsten, 104. *b.*
- Terra acedama, 20. *b. n.*
- Terra calcarea. See chalk, 15. *a.*
- Terra ponderosa, 84. *a.*
- Terra ponderosa aerata, 87. *a.*
- Terra muriatica, 93. *a.*
- Porcellanea, 103. *b. 232. b.*
- Lemnia, 236. *c.*
- Porcellanea Lunenburgica, 251. *b.*
- Tripolitana, 253. *a.*
- Terra pezzana, 735. *a. n.*
- Terra rubrica, 240. *a.*
- Terræ larvatae, 900. *a.*
- Terræ sigillatae, 240. *c. n.*
- Terras, 734. *a.*
- Terras, or Tarras, for making cement, 71. & 72.
- Terre glaise, 234. *b.*
- Terre noire, 234. *b. verte,* 240. *a.*
- Therebinthifusa, 193. *c. n.*
- Thermometer, or rather Pyrometer, of Wedgwood, 228. *a. n.*
- Thermometers, how made? 604. *b. n.*
- Tin, its properties, 618. *a.*
- Nativum, 626. *a.*
- Calci-form, 628. *a.*
- Crystallized, 632. *a.*
- Observations on Tin, 637. *a.*
- fuming liquor of Libavius, stannum corneum, 624. *b.*
- Weights of Tin and Lead mixed together, 625. *c. n.*
- Aurum musivum, 635. *a.*
- Observations, 637. *b.*
- Deflagration of Tin with cupreous nitre, 639. *a. n.*
- 677. *b. n.*
- Its use for looking-glasses, 608. *a. n.*
- This is an old invention, 640. *b. n.*
- Danger still remaining of tinned copper vessels, 641. *b. n.*
- Tin-plate, how made? 641. *c. n.*
- Pewter, 642. *b. n.*

Tin

TABLE OF CONTENTS. 1039

Tin with other metals, 633. <i>b.</i>	Turkey Stone, 216. <i>b.</i> 878. <i>b.</i>
Tin, does it contain arsenic? 620. <i>b.</i>	Turquoise, 686. <i>a.</i>
Tin-glass, 757. <i>a.</i>	———— (false), 61. <i>b.</i>
Tingrains, (like garnets); 633. <i>a.</i>	Tutenago, 776. <i>c.</i> n. 784. <i>b.</i> n.
Tincal, 364. <i>b.</i> n.	<i>Tutia</i> , or <i>Tutbia</i> , 789. <i>c.</i> n.
Toad-stone, 261. <i>c.</i>	V.
Tombac, 708. <i>b.</i>	Vegetable alkali, 329. <i>a.</i>
Topaz, 139. <i>a.</i>	<i>Verde di prato</i> , or <i>di Suza</i> , 106. <i>b.</i>
<i>Tophi</i> , 77. <i>a.</i> 920. <i>b.</i> n.	Verdegris, what? 702. <i>b.</i> n.
<i>Tephstein</i> , 53. <i>a.</i>	<i>Vermeille</i> , garnet, 153. <i>b.</i>
<i>Torrsten</i> , 739. <i>c.</i> n.	Violet rays of light part easily with phlogiston, 438. <i>a.</i> n.
<i>Torstein</i> , 204. <i>b.</i>	<i>Virgula divinatoria</i> , 898. <i>b.</i>
Touch-stone, 883. <i>c.</i> n.	Vital air for the <i>Lamp Furnace</i> ; 995. <i>a.</i>
Tourmalin, 154. <i>b.</i>	Vitriolic acid, its properties, 280. <i>a.</i>
Its electricity, 155. <i>b.</i> n.	———— quantities of metals and earths for its saturation, 282. <i>b.</i> n.
<i>Traaf</i> , 734. <i>c.</i> n.	Vitriolated tartar, 342. <i>a.</i>
Trapp, 880. <i>a.</i>	Vitriolic ammoniac, 369. <i>a.</i>
<i>Trapiskal</i> , 882. <i>a.</i>	Vitriol of copper, 401. <i>b.</i>
Tree-root changed into clay, 233. <i>a.</i> 902. <i>b.</i>	Vitriol of iron, (green vitriol), 404. <i>a.</i>
<i>Trip</i> , 154. <i>b.</i>	Vitriolated nickel, 413. <i>a.</i>
Triple Salts, 417. <i>a.</i>	Vitriol of Zinc, 411. <i>a.</i>
Tripoli's supposed formation, 122. <i>c.</i> n. 253. <i>a.</i>	Vitriol of copper and iron, 424. <i>c.</i>
Trippel or Tripoli. See this last.	Vitriol of copper, iron, and zinc, 425. <i>a.</i>
<i>Tritura rubra</i> , 739. <i>b.</i>	Vitriol of iron and zinc, 426. <i>a.</i>
Trough for washing the ores, 974. <i>c.</i>	Vitriol of iron and nickel; 427. <i>a.</i>
Tufa, 920. <i>b.</i> n.	Vitriolic ammoniac, 369. <i>a.</i>
Tungstein, 46. <i>b.</i>	Vitriolated barytes, 382. <i>a.</i>
———— red, 79. <i>b.</i>	Vitriolated magnesia, 384. <i>b.</i>
———— flesh-coloured, <i>ib.</i>	Vitriolated calx, (gypsum), 377. <i>a.</i>
Tungstenic or Wolfranic acid, its properties, 304. <i>b.</i>	
Tung-spat, 84. <i>b.</i>	
<i>Turba</i> , 907. <i>c.</i>	
Turf, 407. <i>c.</i> n. 907. <i>c.</i>	
<i>Turkina</i> , (<i>pietra</i>), 82. <i>b.</i>	
<i>Turkish earth</i> , 237. <i>b.</i> n.	

Volatil

1040 TABLE OF CONTENTS.

- Volatil alkali, 337. *a.*
 Volatil alkali aerated, 374.
 Volcanic explosions in Iceland, in 1783. *Add to page 910.*
 Volcanic metals, 910 *b. n.*
 Volcanic productions, 909. *c. and foll.*
Vulcanorum Scoriæ, 909. *a.*
- W.
- Wadd, its properties and uses, 451. *a. 454. b. 455. c.*
 Wadd, (black), 859, *b. n.*
Walkera, 236. *b.*
 Water, what? according to the new theory, 444. *b. n.*
 Not produced, but devolved. *Add to page 445.*
 Water opal. 183 *b.*
 * *Weights*, the nicest and general, how easily made, 1010. *a.*
Weiseriz, 556. *a.*
Weises eisenritz, 57. *b.*
Weises eisen Spath, 729. *b. n.*
Weissguldern, 555. *a.*
 Whetstone, 877. *b.*
 White copper, 710. *a. and c. n.*
 White lead, how made, 648. *b. n.*
Wismuth, 757. *a.*
 Wolfram, 208. *c. n.* 866. *a.*
 Wolfranic, or Tungstanic acid, its properties, 304. *b.*
Wurffelspath, 88. *a.*
- X.
- Xilansbrax*, 482. *c.*
- Z.
- Zaffre, 835. *b. n.*
 Zeolite, 244. *a. purus*, 246. *c.*
 ——— Lapis Lazuli, 247. *a.*
 ——— *Spatofus*, 249. *a.*
 ——— *Crysalizatus*, 250. *b.*
 Observations on Zeolites, 251. *a.*
 Found in lavas, 252. *b. n.*
Ziment copper, 5. *a.*
 Zinc, its general properties, 769. *b.*
 ——— changes copper into gold colour, 708. *c. n.*
 710. *c. n.* 772. *a.*
 ——— is attracted, and attracts, like the load-stone, 772. *c. n.*
 ——— becomes electrical by friction, 772. *c. n.*
 ——— native Zinc, 773. *a.*
 ——— calciform, 774. *a.*
 ——— *lapis calaminaris*, 775. *a.*
 Zinc discovered by Dr. Lawson in England, 785. *c. n.*
 ——— mineralized Zinc, 775. *c.*
 ——— zeolythiform, 777. *a.*
 ——— *Pseudo galena*, 779. *a.*
 ——— Zinc spat, 782. *c. n.*
 ——— *glanz blende*, 783. *a.*
 ——— vitriolated, 784. *a.*
 Observations on Zinc, 784. *b.*
 ——— its smelting, 788. *and foll. n.*
Zinethum, 769, *b.*
Zinn, 618. *a.*
Zeeblitz serpentine, 103. *a.*
Zenites, 790. *b. n.*

T H E E N D.

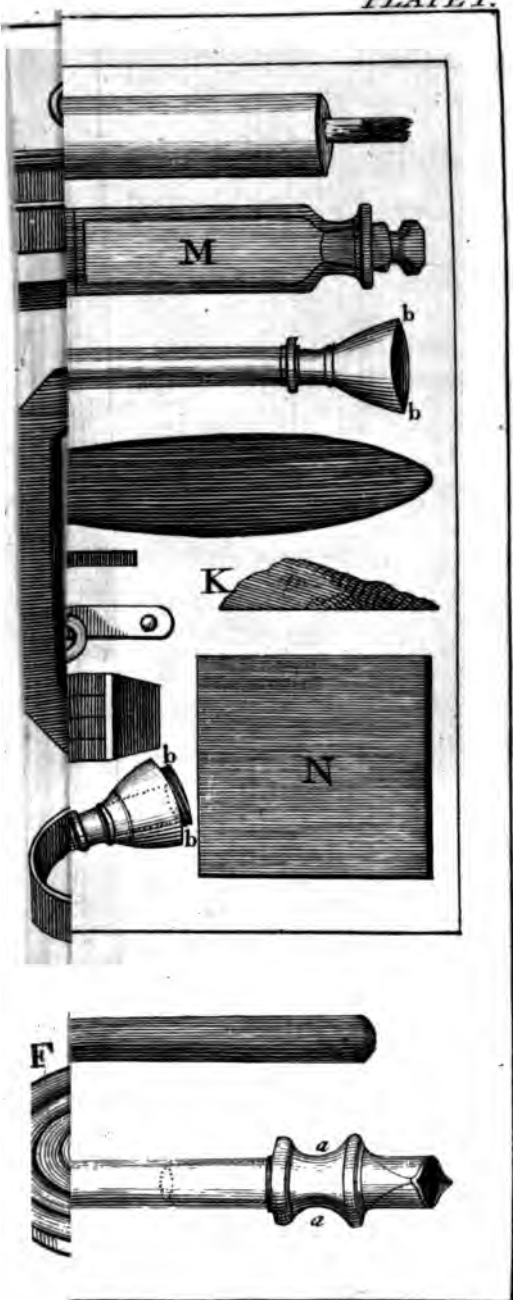


Fig.



Fig.





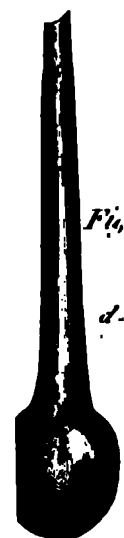


Fig. 23





Fig. 1.



Fig. 6.



Fig. 7.

Fig. 2.



Fig. 3.

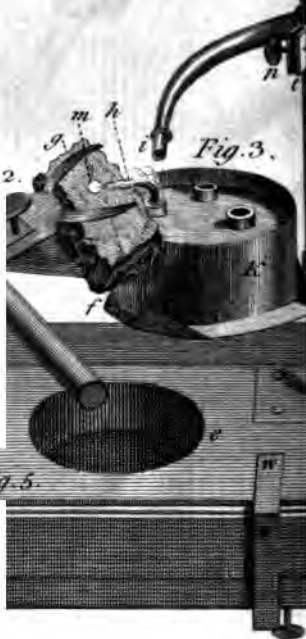


Fig. 5.

